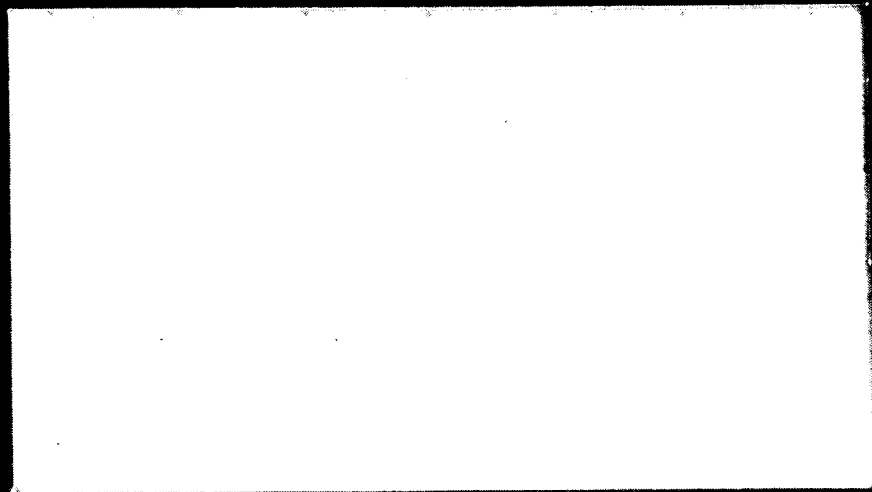
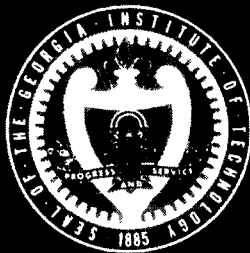


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DESIGNING TOMORROW TODAY

THE GEORGE W. WOODRUFF SCHOOL OF
MECHANICAL ENGINEERING

ME 4182
MECHANICAL DESIGN ENGINEERING

NASA/UNIVERSITY ADVANCED SPACE DESIGN PROJECT

SEMI-AUTOMATED 10-METER
MARTIAN DRILLING SYSTEM

March 1986

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ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Winter 1986

Mr. James Brazell

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Outline

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Abstract :

We propose a drilling and coring system that is an extension of the technology presently used on Earth for the Manned Mars Mission. This extension of technology will include the addition of feedback controls for optimum drilling and remote operation. Proposals on power, communications, structures, materials and drilling equipment are provided.

PROBLEM STATEMENT

Background: In the mid 1970's Viking Missions began exploring mars by taking photographs and surface samples. Manned missions are being planned for the future. To help study Mars, soil and rock samples will need to be recovered and returned to Earth. The crews will also need to perform construction, place scientific equipment, and perform excavation projects which all require hole drilling.

Although many of the drilling techniques on earth can be used on Mars, most are not feasible because of cost, power requirements, weight, or soil sensitivity. There are several traditional rock drilling techniques that are used to drill a hole recover core samples.

Rotary drilling consists of turning a drill bit while applying a downward force on it. There are several different style bits that may be used with this technique.

Percussive drilling consists of repetitive impaction of the bit into the rock. The impact can be delivered from the top of the drill and transmitted through the drill rods to the bit, or the impact mechanism may travel down the hole with the bit. Most percussive drilling techniques employ a slow rotary action to speed the drilling rate.

Both of these drilling methods must use a fluid under

pressure or a compressed gas to remove drilling chips and to cool the bit.

For sampling loose material, a split spoon sampler is used to obtain a core. One method used to recover a rock core is to pull the drill bit containing the core out of the hole, removing the core from the bit, and putting the bit back into the hole. Another way to recover a rock core is the wire line method in which the core is recovered without removing the drill from the hole.

There are several advanced drilling methods available, but these techniques require more energy to operate than do the traditional techniques.

Performance Objectives: The performance objectives of the design problem is to create a 10-meter drill which can recover core samples and drill a variety of holes and hole sizes. The drill will also perform from vertical to 30 degrees in one direction. Since any location on Mars is possible and the composition of the crust is unknown, the drill must be insensitive to rock or soil types. The drill will be controlled from a manned substation for much of the operation. This substation will control a number of drills in real-time. The drill should be light weight and modular in design for mobility. Because repair equipment and maintenance personnel are limited on Mars, high reliability is necessary to maintain full operation.

Constraints: The design of this system is limited by cost, size, power requirements, and other constraints. The reliability, light weight modular design, and cost mentioned above are also design constraints. The dimensions of the drill, power supply, and other equipment are limited by the weight, mobility, feasibility of transportation to Mars, and cost reduction. Because the drill is controled from a substation, the drill needs to be automated, semi-automated, or remotely controlled. The operator must be able to control a number of drills simultaneously in real-time. The drill operators will be in space suits, so human factors are essential, especially in the removal of cores, transportation, and simple repairs. Temperature variations, unknown rock and soil compostion, low gravity, and low density atmosphere have to be considered in the design and construction of the equipment. Sand storms, the lack of an ionosphere, and low density atmosphere exclude many options for a communications system. Because there is only one geosynchronous satelite, the substation can control drills on less than half of Mars.

Mars: General Information

The purpose of retrieving core samples is to determine the composition of the Martian crust and its geologic past. Although probes have landed on Mars there is still very little known about the planet. Some knowledge of the atmosphere and crust composition does exist.

The Martian atmosphere consists largely of CO₂ at a very low pressure and density. Along with these atmospheric conditions, the gravity is 12.375 ft/s which is approximately 38% of earth's gravity. The atmospheric conditions are such that dust storms may develop, some lasting up to one year with winds reaching speeds as high as 200 miles per hour. Because of low atmospheric pressure and density these winds have the same effect as 20 mph wind on earth. The surface of mars is covered by dust carried by the dust storms.

The emerging picture of Mars also includes a crust made up of volcanic basalts, the same rocks commonly present in terrestrial provinces and throughout the lunar maria. Under oxidizing conditions the iron rich minerals of the basalt probably weather to form a mixture of yellow, limonite

coated grains and fine grained clay mineral. There is evidence that a thick permafrost covers the entire planet and extends to a depth of about 1 Km at the equator and several kilometers at the poles.

Assumptions

- 1) There will be relay link stations for communications if the habitat or remote substation is beyond the line of sight.
- 2) A Martian rover with the capability of lifting and transporting the drilling system is being designed by the University of Wisconsin.
- 3) The rover will also be able to return core sample containers, discharged batteries, and empty compressed gas cylinders to the base station and return them.
- 4) The base station will have the capability to compress CO₂ that will be used to remove the drilled sediment and cool the bit.
- 5) There will be a pressurized transport container to hold the core samples.
- 6) A hand held drill similar to the one used in lunar missions is used to drill the hole that are required to set the slip joint anchors.
- 7) There is a high percentage of rock in volcanic areas where many of the core samples will be taken.

Drilling Methods

This drill uses a rotary diamond bit and a 3 inch diameter wire line core barrel to obtain a 2-3/64 inch diameter core sample 5 feet in length. A starter barrel of 18 inches is run through 2 or 3 times so that a core barrel can then be set down in the hole. As the core barrels fill-up they will be recovered by the wire-line method. These will be done by a robotic arm that is responsible for picking up empty core barrels from the core barrel rack at the side of the drill and placing them in the drilled hole to continue drilling. This operation will be monitored via camera, placed on the tripod which will relay the picture to the remote substation.

To achieve the 30 degrees from vertical angle the drill head is mounted on a plate that can rotate 360 degrees. The down-force required for drilling and recovering core samples, about 7000 pounds, is produced by two hydraulic cylinders. To clear the hole of the drilling chips compressed CO₂ is pumped through a water swivel at the top of the drilling rod down the core barrel then across the top of the bit cooling it. When the CO₂ reaches the bit it

expands causing more cooling. The compressed CO₂ then pushes the sediment up the hole between the rod and the wall until it reaches the top where the sediment enters the atmosphere or falls to the ground around the drill hole.

Drilling Structures

The drill sits on a sled that is made of aluminum which is then anchored by four slip joint anchors. These anchors are placed in small holes, .75 inches, that are drilled in a 36x40 inch rectangle. These slip-joints consist of a long bolt that goes through two slip wedges into a nut. The anchors are set by using a T-handle that fits on the two tabs on the bolt, and tightening the bolt causing the overall length to shorten thus causing the slip wedges to expand and tighten against the sides of the hole. A tripod is used to aid in the removal of the core barrels when they become full.

Power

There are a variety of power systems that can be used, but providing a light weight system is a difficult task. The drilling station needs between 15 and 20 Horsepower for the drill plus wattage for the robotic arm, the camera, the communication system, and a heating system. Compared to the drill's power requirements, the rest of the power consumption is negligible. Nuclear reactors, radio isotopes, fuel cells, combustion engines, solar collectors, and batteries were all investigated. Because of radiation risks and cumbersome shielding, nuclear reactor systems were disregarded. Also eliminated were solar collectors, because on Mars a collector would need to be the size of a football field to produce the necessary power.

Internal combustion engines can easily produce the necessary Horsepower, but they would have many problems. The exhaust will pollute the martian atmosphere. The engine will weigh at least 100 pounds without fuel. The high fuel consumption, 2 or 3 times greater than fuel cells, reinforces the case for not using internal combustion engines.

If the power system chosen produces electric power, it will need to be converted into mechanical power. A dc motor was developed for the Space Shuttle Orbiter elevon which provided approximately 17 HP. This motor uses a permanent magnet rotor and air cooled stator windings, which can be achieved with some of the compressed CO₂. The motor designed was 11.25 inches long and 17.16 lbs. This high efficiency, light weight motor sounds desirable but it requires 300 volts and around 40 amps.

Providing a large amount of electrical power with radio isotopes is not desirable. The weight of a 500 watt isotope system is over 100 lbs. Also, the amount of fuel necessary to produce high power may be difficult to obtain.

Rechargeable batteries are more suitable to this application, because they can be recharged at the habitat. This recharging requires fewer batteries to be delivered to Mars, reducing weight and its associated cost. A high-energy-density rechargeable battery, Li-NiF₂, discharges in about 10 hours with about 100 W-hr/lb of power. A large mass is needed despite the high density.

The best power system appears to be fuel cells along with the above mentioned dc motor. Fuel and fuel tank weight, of 1.5lb/kW-hr, will be approximately 450 lbs for a 20 hour drilling operation. Even though this seems to be a marginal selection, it has an advantage. It produces 1 lb/Kw-h of water which can be used by the habitat.

If the main power system fails, a backup system will take

over the responsibility. During a main power system failure, only the communications system will be operating. The Li-NiF_2 battery, discussed before, can be used in a pair combination, as the backup system. Two should be used to allow for a 20-hour discharge rate.

Normally the drilling system would provide some heat after initial warm-up. If the main power system failed, then the drill would not be providing heat. The heating system would have to be maintained in a power failure. Because of the cold temperatures on Mars, it would be better to use a low-temperature battery. This is so that in a heating system failure, some power could be provided. Some of these low-temperature batteries have lead-sulfate cathodes in solutions of ammonia. These have been shown to operate as low as -73 degrees Celsius.

Communications

There is a real-time data transfer requirement between the drill station and the manned substation. The data being transmitted will include continuous video pictures from the camera, communications from astronauts working on the drill station, and information about the drill bit, robotic arm, core barrel, and drill speed. Because low power transmission of real-time pictures cannot be achieved with satellites, line of sight communications must be used. Knowing this, a radio frequency transmission system will be implemented. The video picture transmission will occur at a different frequency than the astronauts.

The temperature and pressure of the drill bit, the rpm's of the motor, the drill speed, the drilling rate and CO₂ tank pressure will be sent along the same frequency using time division multiplexing. There will be a seventh time division for 2-way controls with the robotic arm. When the core barrel pressure sensor detects the need to remove barrels, the signal overrides the robotic arm controls and informs the drill controller. Since the robotic arms primary purpose is to remove the core barrel, robotic

controls will rarely be transmitted when the sensor is triggered. The emergency shutdown warning signal has highest priority on this line.

The safety of the astronauts maintains highest priority. A transmission frequency is assigned strickly for communications with astronauts working on the drill station. Two-way real-time communications with the substation is provided. This system will be a hook up system which can be used without the main system. The astronauts will connect their system to the larger one so that better transmission and receiving will occur. Also the small transportable battery system which the astronauts carry will not be drained because they will be using the power from the drilling station.

The receiving will include the commands for changing CO₂ tanks, adjusting the hydraulic down force, adjusting the transmission, and turning the power on or off along with the communications with the astronauts and the robotic controls. The CO₂ tank control is received through the same window as the CO₂ tank pressure is transmitted. Also sharing windows are the hydraulic adjustments and the bit pressure, the drill speed and the transmission controls, and the motor RPM's and the power ON/OFF signal.

Frequency modulation and demodulation can be used to implement this system. Each part of this communication

system is often used on earth, so there will be few problems implementing this system. Radio relay links can be used to communicate beyond the line of sight.

CONTROLS

The controls are generally run through an on board computer with an override by the manned substation. The information received from and sent to the substation is also sent to the computer.

When the power on signal is sent, the on board control system begins operation. The motor rpm, the drill speed, and the drilling rate are the parameters needed to control the transmission system. The pressure monitors will switch the input tanks as one runs low of CO₂. The amount of CO₂ being released is controlled by the bit temperature.

The robotic arm will be programmed to remove cores and replace empty drills. The arm has two telescopic extenders allowing an overall length of six feet. The robotic arm knows to remove the core sample because the pressure of the core piston will close a switch at the top of the barrel. This closed circuit warns the motor to turn off and the robotic arm to remove the core. The manned station is capable of overriding the programming

Construction and Assembly

Construction of the drilling system will require at least two people for effective assembly. First, the holes will be drilled to anchor the drill skid by using a hand held drill to drill 3/4 inch holes in a rectangular pattern, 36x40 inches. Then setting the anchors and securing them will follow. A hoist on the land rover will be required to lift the drill and set it in place. After aligning the drill with the anchors, they must be secured to the drill via nuts and washers. The hoist also will aid in the construction of the tripod. First the legs of the tripod are assembled by placing the male and female ends of the legs together and inserting the connecting pins. Next the core barrel and drill rods will need to be set. Referenced from the rear of the drill they will be located on the right side, in the middle about three feet from the drill. Finally, connect all power sources and the system is ready for operation.

Materials

The drilling equipment must be built using materials that will minimize weight while maintaining enough strength and durability for the necessary drilling operations. In an attempt to keep the martian equipment similar to what is used on earth, we plan to model as many parts as possible from the equipment currently used on earth.

Although the equipment will be built with as many light weight parts as possible, some parts will have to be made of steel. Due to the low temperatures on Mars, all steel parts must be made from a high carbon steel because low carbon steels have poor properties at low temperatures. All casings and most structures will be manufactured from aluminum alloys or composite materials. This includes the pump housing, the main sled mounting plates, the tripod, and the robotic arm extensions. All shafts and bearings will be made of steel. This includes the shafts and bearings inside the pump, the hydraulic cylinder push rods, and the joints and bearings in the robotic arm.

Operational Procedures

After assembling and anchoring the drill rig the astronauts are not needed at the drilling station for the drilling operation. When starting a new hole, a starter core barrel will be used. This core barrel is 18 inches in length and is used for the first three cores. This makes the hole deep enough to insert a five foot core barrel. As the drilling proceeds, drill rods are added to the rod until the desired depth is reached. Core samples are removed from the outer core barrel using a cable pulled up by an electric wench on the surface. The robotic arm retrieves the full core barrel and places an empty core barrel down the hole. To ensure proper operation of the drill the bit temperature, bit pressure, drill speed, motor rpm, drill rate, and pressure in the CO₂ tank are measured. This data is analyzed and the proper adjustments are made by the feedback control system or by an operator from a remote control substation. If the bit pressure is too high or too low, the hydraulic cylinders will be adjusted until an acceptable bit pressure is reached. The transmission gearing is controlled by the motor rpms and drill speed. When the transmission

gearing is adjusted to achieve the desired drill speed and the proper bit pressure is obtained, the flow of CO₂ is adjusted to properly cool the bit.

The most frequent maintenance operations will be to exchange charged batteries for discharged ones, and to replace empty CO₂ tanks with full ones. During these routine visits, astronauts will check the lens shield on the video camera for pitting and replace the shield if it is damaged. Less frequent maintenance includes joint lubrication and cleaning when necessary.

Even with a strict maintenance schedule and proper operation, the drill may fail to perform its task. The most probable cause for failure would be a dull bit. This problem can be cured by simply replacing the bit. A bit can become dull from normal wear or from overheating. Overheating may be caused by a less than adequate flow of CO₂, too much down force or too high a drill speed. These destructive problems may arise from equipment trouble or operator error.

Basic guidelines for proper drill operation using NQWL bits:

Bit load = 4000 to 8000 pounds

Drill speed = 800 to 1200 RPM

Drill rate = 3 to 4 in/min

To calculate the RPI index, divide the drill speed by the drill rate. This gives the number of revolutions the drill turns for each inch of penetration. For this drill, the RPI index should never be much lower than 250, as bit wear would be accelerated. to prevent polishing of the bit, the RPI index should not exceed 300.

Human Factors

Since an astronaut on Mars has very limited sensory perception and limited physical abilities, his activities should be designed with his limitations as parameters. Although there is very little gravity on Mars, the mass and thus, the inertia of a moving object does not change.

Although this drilling rig is as automated as possible, humans on Mars will have to initially set up the drill rig and perform maintenance operations. The astronauts will have to locate the anchor positions and then use a hand drill to drill 3/4 inch diameter holes for anchor placement. After the anchors are placed in the holes, they must be expanded using a special T-handle tool. When all four anchors are set, the drill sled is placed with the protruding anchors in the holes of the mounting tabs. A washer and nut is then placed on each anchor and tightened down with a conventional type wrench. The drill must then be assembled on the sled.

When assembling the tripod, astronauts will have to mate the two halves of each leg and insert two retaining pins at each joint. The CO₂ tanks and batteries will have to be easily exchanged by an astronaut for ease of maintenance.

Alternate Designs

Many of the alternate topics are discussed under their separate headings.

Drilling: There are several alternatives to drilling such as percussive, laser and water jets. There are also combinations of drilling techniques, such as rotary percussion. The laser and water jets require large amounts of energy which make them impractical. A percussive type drill, similar to a jack hammer, is a good choice since the compressed CO₂ is readily available at the site.

Power: Two good alternatives to power sources are internal combustion engines and air motors. The IC engines would require oxygen bottles, which could be acquired from the habitat, to run the engines. Also, with the IC engine an electric generator could be added to produce power for units such as multi-stage pumps or robotic arms and cameras. The air motors can also be used to power the drill. The air motors could be powered by compressed CO₂ which is already being used to clear the hole. A great deal of compressed gas is necessary to use air motors.

Appendix

ME 4182 GROUP #3

AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: January 14, 1986

Week of: January 6, 1986

Progress Report #1

- 1) Used CatCom to find sources pertaining to Mars and its environment.
- 2) Located drilling equipment technology and manufacturers, using CatCom and products catalog of the VSMF.
- 3) Searched through University Studies, Mars Project from John Butler.
- 4) Discussed the problem and possible solutions.
- 5) Drafted a problem statement.

ME 4182 GROUP #3

AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: January 21, 1986

Week of: January 13, 1986

Progress Report #2

- 1) Continued research on drilling methods and equipment.
- 2) Continued research on the surface environment, atmosphere, and geological composition of Mars.
- 3) Used Engineering Index Monthly, Index to the Transactions of ASME, and Index of Science and Technology to find keywords to conduct an on-line database search.
- 4) Submitted a purchase request to Price Gilbert Memorial Library for an on-line database search.
- 5) Discussed with Gary McMurtry our project and the problems we are having.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: January 28, 1986

Week of: January 20, 1986

Progress Report #3

- 1) Attended meeting on drilling conducted by Mr. Carroll Crowther and Mr. David Federer.
- 2) Final problem statement was discussed and written.
- 3) Continued research on drilling and the planet Mars.
- 4) Talked with reference librarian, Mr. John Sherman, conducting database search.
- 5) Communication options were discussed with Dr. Steffes of The Electrical Engineering School.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: February 4, 1986

Week of: January 28, 1986

Progress Report #4

- 1) Discussed and proposed Martian landing sites.
- 2) Began construction on the design chart for our drill.
- 3) Looked through the International Association of Drilling Contractors (IADC) Drilling Manual.
- 4) Looked through commercial drilling brochures from several drill manufacturing companies.
- 5) Talked with Mr. John Sherman about the status of our database search.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: February 11, 1986

Week of: February 4, 1986

Progress Report #5

- 1) Developed a report outline.
- 2) Checked out a map of Mars from the library.
- 3) Looked at some of the articles from our database search.
- 4) Visited the Fern Bank Science Center Library and the Mars exhibit.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: February 18, 1986

Week of: February 11, 1986

Progress Report #6

- 1) Selected a back-up power supply system.
- 2) Conducting research on multi-stage pumps.
- 3) Conducting research on hydraulic fluids.
- 4) Contacted Jerry Edwards at the U.S. Forestry service about light weight anchoring systems.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: February 25, 1986

Week of: February 18, 1986

Progress Report #7

- 1) Met with Jerry Edwards of the U.S. Forestry Service and discussed light-weight anchoring system.
- 2) Started initial calculations to determine the volumetric rate of CO2 needed to cool the drill bit and to remove drill cuttings.
- 3) Started initial calculations to determine the H.P. required for drilling.
- 4) Discussed robotic arm assembly and job functions.
- 5) Discussed core sample size and drilling holes for placement of scientific instruments with Dr. Wampler of Geophysical Sciences.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Date: March 4, 1986

Week of: February 25, 1986

Progress Report #8

- 1) Learned how to use IBM CAD system in French Building.
- 2) Created two drawings using IBM CAD system.
- 3) Visited Brainard and Kilman and talked with Mr. Brainard about small drilling rigs.
- 4) Continued calculations on required up-hole velocity.

ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

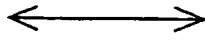
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Week of: March 4, 1986

Progress Report #9

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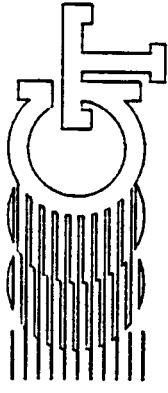
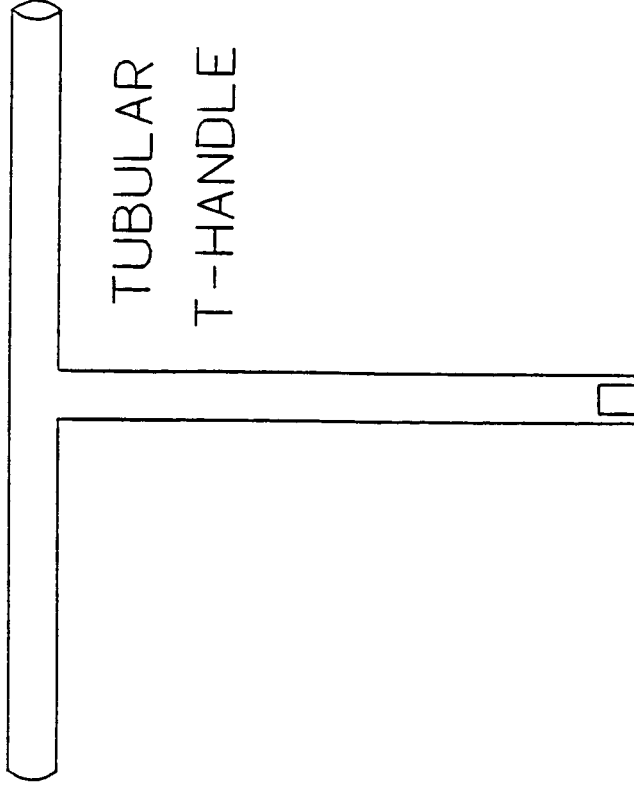
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DESIGN: MWR DATE 2-27-86

CHECK: DBW DATE 2-28-86

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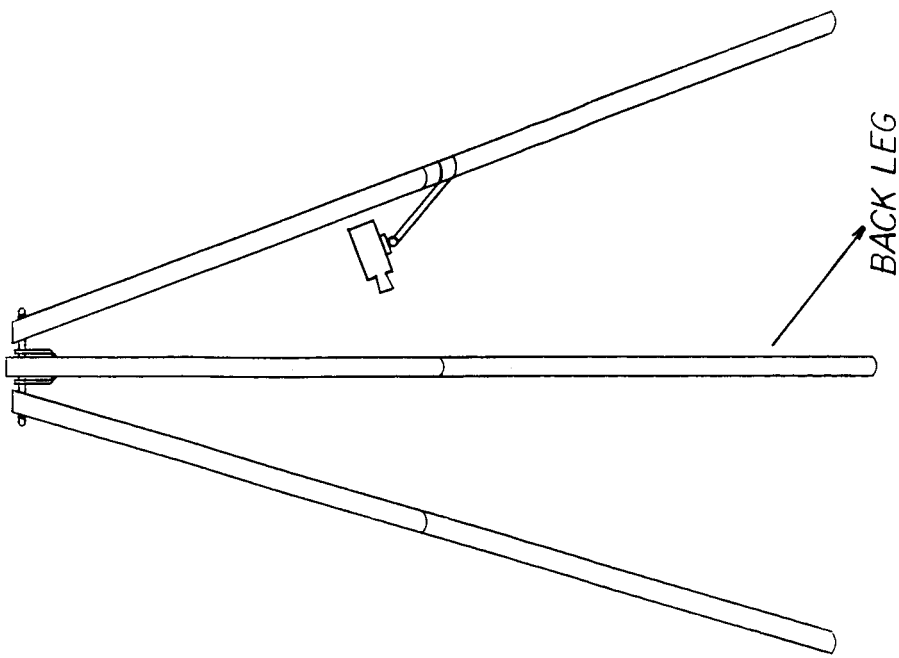
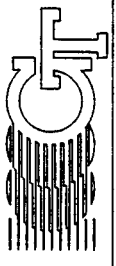
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LAST UPDATED : 2-28-86



GEORGIA TECH
COLLEGE OF ENGINEERING

DEPT. : ME4182 GROUP #3

TITLE : LIGHTWEIGHT DERRICK

DESIGN: DBW DATE 2-28-86

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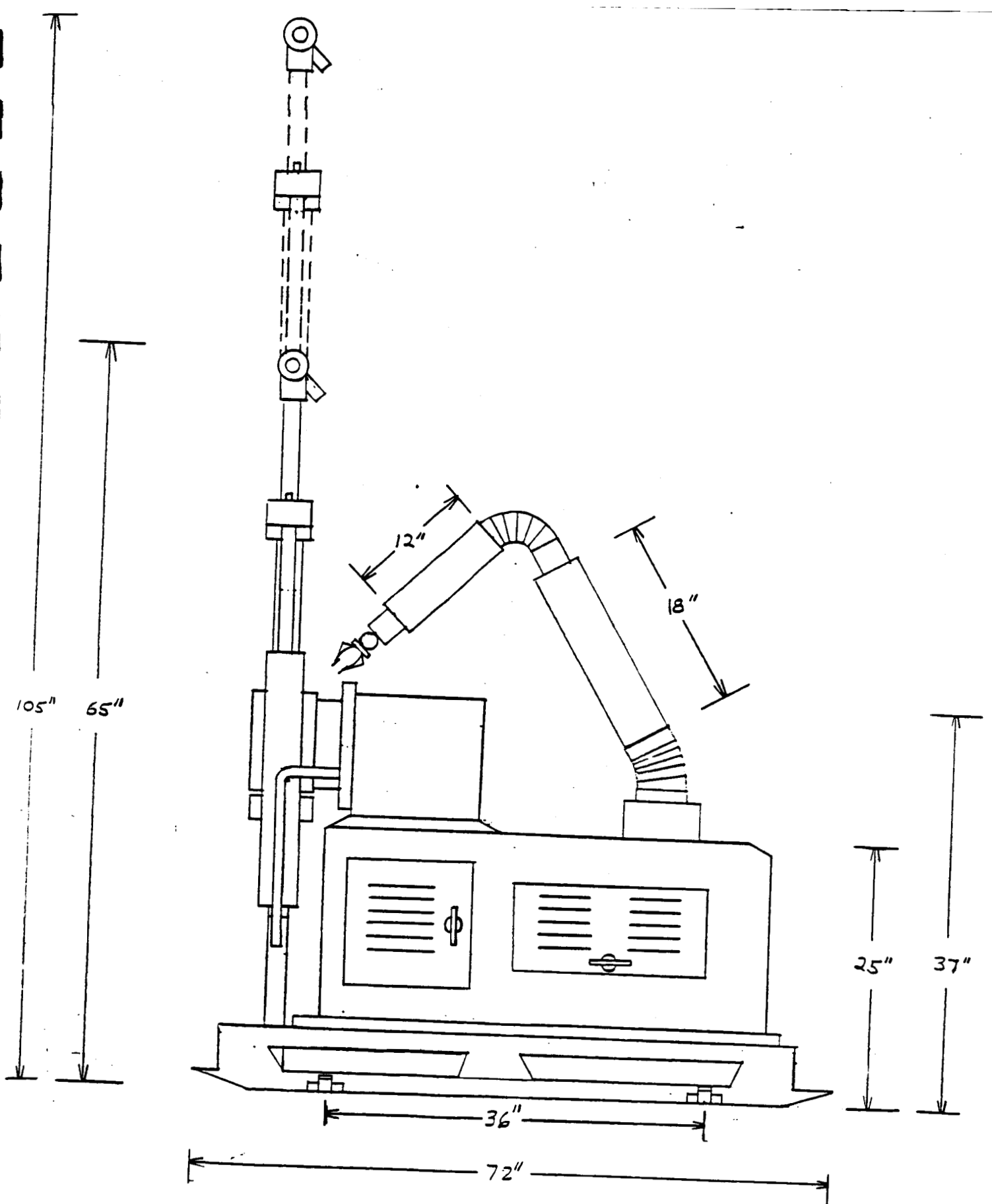
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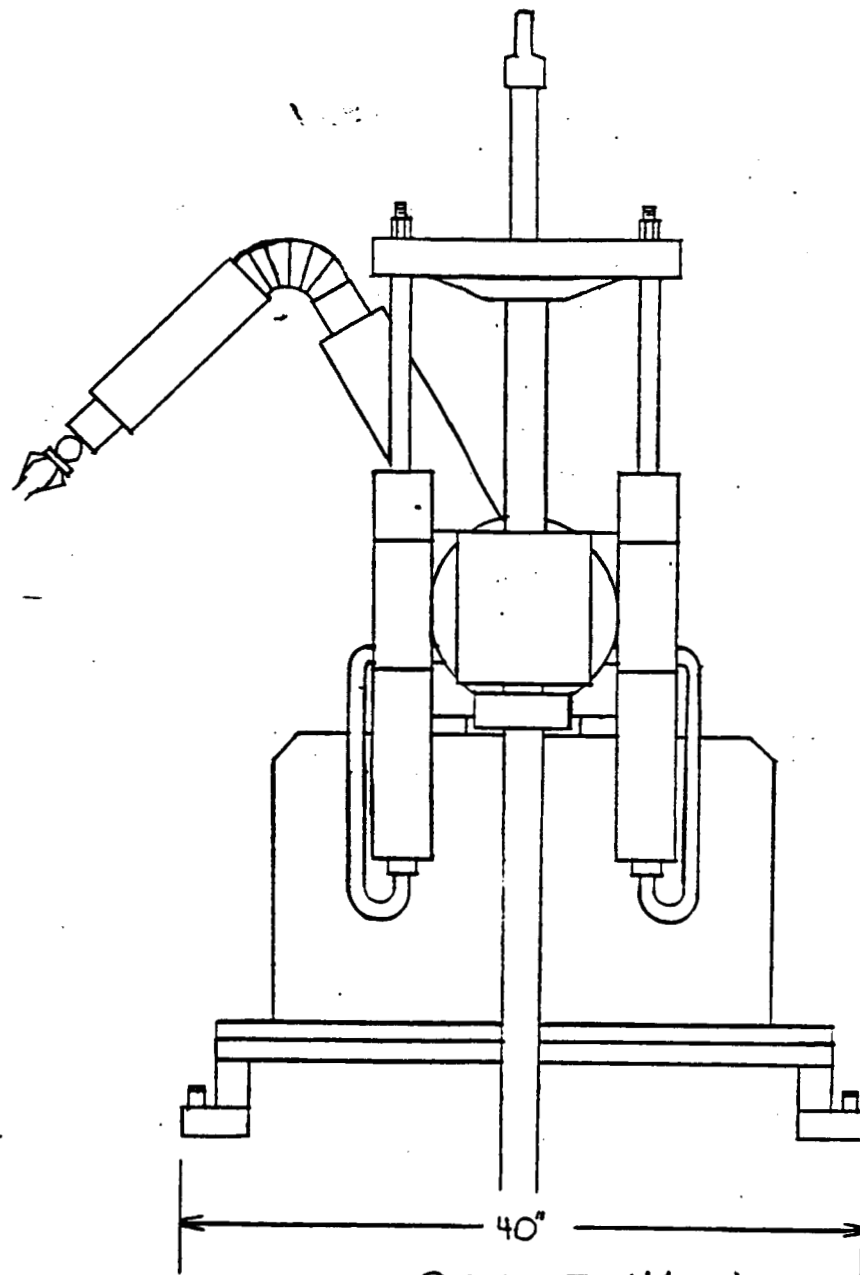
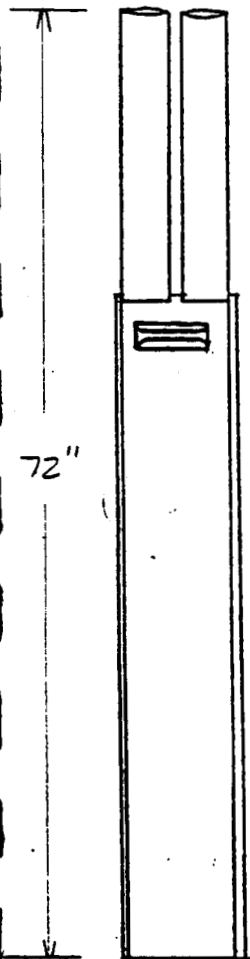
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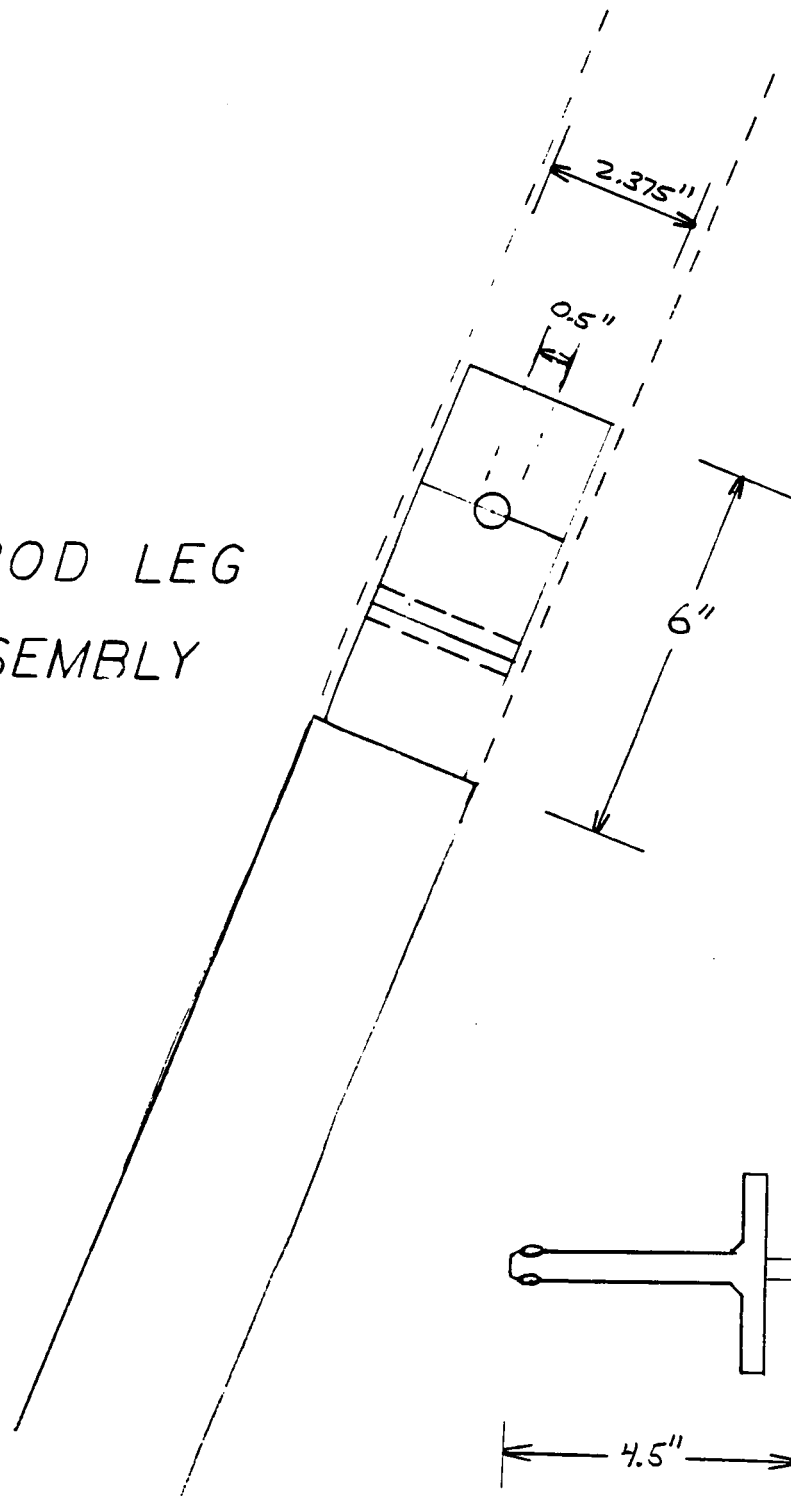


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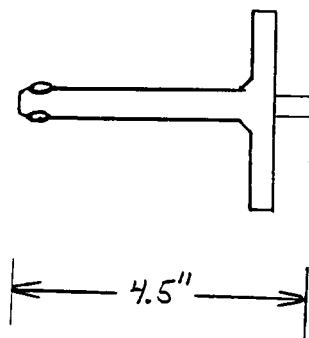


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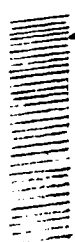
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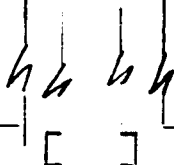


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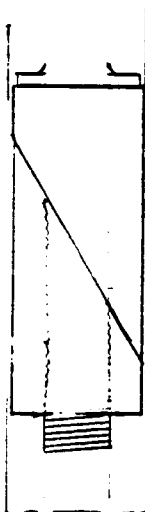


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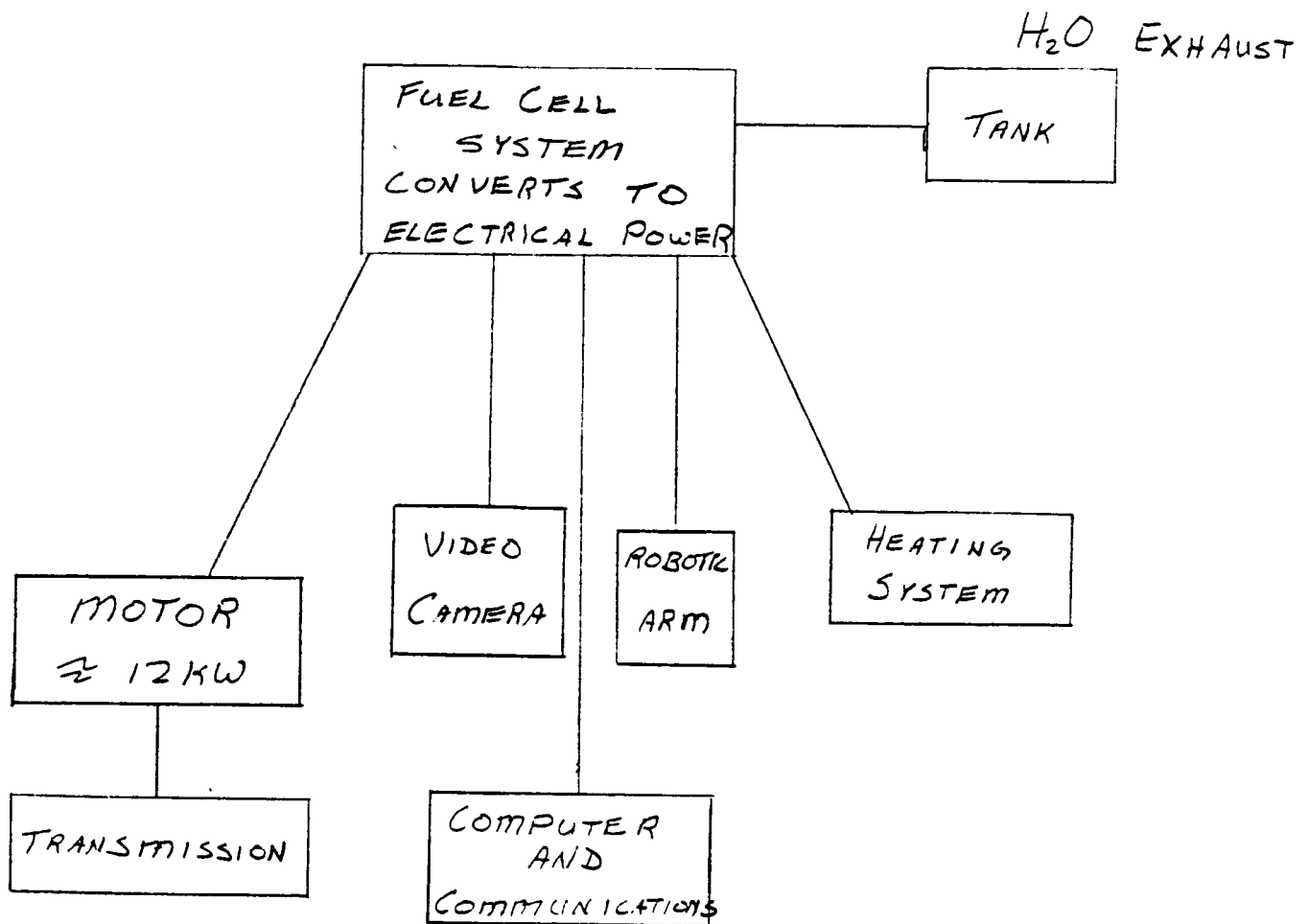


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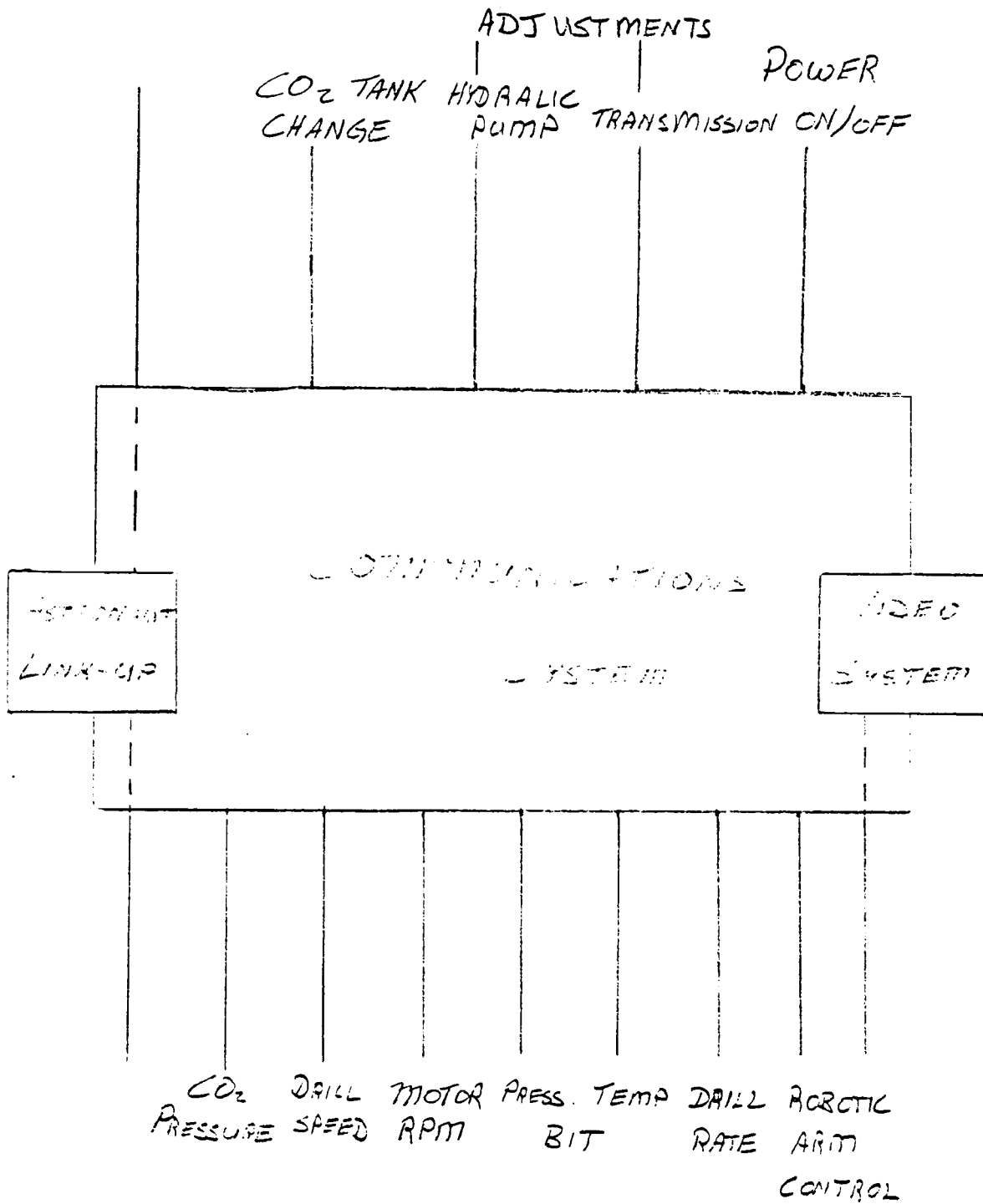


3/4"

POWER DISTRIBUTION



RECEIVING



— TRANSMITTING

BIT
TEMP.

BIT
PRESS.

DRILL
SPEED

DRILL
RATE

CORE
SAMPLE
PRESS.
SWITCH

POWER
ON/OFF

COMPUTER

HYDRAULIC
SYSTEM

RPM

DC
MOTOR

TRANSMISSION

ROBOTIC
ARM

tank 1

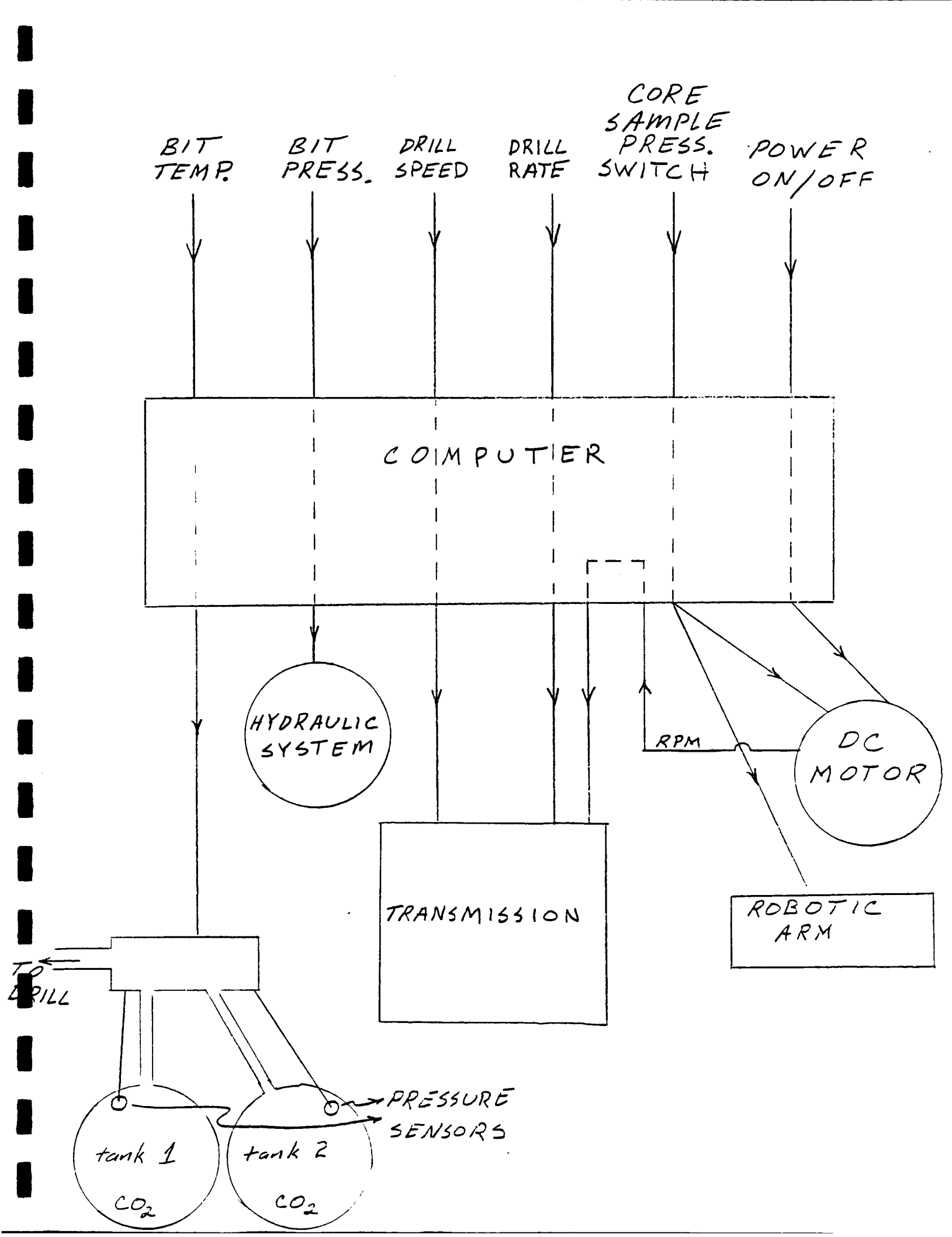
CO₂

tank 2

CO₂

PRESSURE
SENSORS

TO
DRILL



Up-Hole Velocity

g : gravity (12.375 ft/sec²)

P_1 : Down-hole pressure

P_2 : Exit pressure (.008 atm; .1329 lbf/in²)

V_1 : up-hole velocity (25 ft/s)

V_2 : Exit velocity (1 ft/s)

ΔZ : change in height (35 ft)

ρ : density (1.15×10^{-4} lbm/ft³)

g : specific gravity. (1.52)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f$$

To simplify calculations the head loss due to friction (h_f) is assumed to be negligible.

$$\frac{P_1}{\rho g} = \frac{P_2}{\rho g} + \left(\frac{V_2^2 - V_1^2}{2g} + (Z_2 - Z_1) \right) + h_f$$

$$\begin{aligned} P_1 &= P_2 + \rho g \left(\frac{V_2^2 - V_1^2}{2g} + Z_2 - Z_1 \right) \\ &= .1329 + 1.75 \times 10^{-4} \left(\frac{1^2 - 25^2}{2(12.375)} + 35 \right) \\ &= .1346 \text{ lbf/in}^2 \end{aligned}$$

$$P_1 = \underline{.0092 \text{ atm}}$$

To compensate for head loss due to friction a pressure of .015 atm is used.

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.01250	.00049	.00001

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00000085	.00000003	.00000033

Constants

Density	Coef. of Drag	Area(Ft)
.00200	.47000	.00000341

Velocity(Ft/sec)
14.30

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.02500	.00196	.00007

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00000682	.00000021	.00000262

Constants

Density	Coef. of Drag	Area(Ft)
.00200	.47000	.00001364

Velocity(Ft/sec)
20.22

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.05000	.00785	.00052

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00005454	.00000169	.00002096

Constants

Density	Coef. of Drag	Area(Ft)
.00200	.47000	.00005454

Velocity(Ft/sec)
28.60

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.01250	.00049	.00001

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00000085	.00000003	.00000033

Constants

Density	Coef. of Drag	Area(Ft)
.00140	.47000	.00000341

Velocity(Ft/sec)
17.09

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.02500	.00196	.00007

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00000682	.00000021	.00000262

Constants

Density	Coef. of Drag	Area(Ft)
.00140	.47000	.00001364

Velocity(Ft/sec)
24.17

UP-HOLE VELOCITY

Dimensions of particle

Radius	Area	Volume
.05000	.00785	.00052

Weight on Mars

Earth weight	Mass	Weight(MARS)
.00005454	.00000169	.00002096

Constants

Density	Coef. of Drag	Area(Ft)
.00140	.47000	.00005454

Velocity(Ft/sec)
28.60

Anchoring Bolts - Requirements.

Maximum Force = 9000 lbf

Number of Fasteners = 4

Material: ASTM A574

Yield Strength = 160,000 psi

Safety Factor = 4

Force per fastener = $\frac{(9000 \text{ lbf})}{4 \text{ bolts}} = 9,000 \text{ lbf/bolt}$

Tensile Area Required = $\frac{9000 \text{ lbf}}{160,000 \text{ lbf/in}^2} = .0563 \text{ in}^2$

Tensile Area of $\frac{5}{16}$ " UNF bolt = .0580 in²

- Required: 4 ASTM A574 $\frac{5}{16}$ " UNF fasteners.

SHERMAN
QUERY 2294

01/24/86
1976 - NOV 1985
COMP

- 1 ROCK-DRILLS.DE. OR ROCK-DRILLING.DE.
RESULT 707
- 2 1 AND (AUTOMAT\$3 OR (REMOTES\$2 ADJ CONTROL\$2))
RESULT 20
- 3 1 AND (NUCLEAR OR ELECTRIC\$4 OR ELECTRONIC\$4)
RESULT 37
- 4 2 OR 3
RESULT 56

AN EI 8511-099583.
AU Bristow-N.
IN Perard Torque Tension Ltd.
TI COMPUTERISED DRILLING AND TUNNELLING.
SO Colliery Guardian v 233 n 7 Jul 1985 p 294-296, 298-299.
MJ COAL-MINES-AND-MINING.
MN Tunneling.
ID COMPUTER-APPLICATIONS.
XR ROCK-DRILLING: Equipment. ROCK-DRILLS. TUNNELS-AND-TUNNELING:
Computer-Applications.
IS 0010-1281.
CC A405. A503. A723.
CD CLGUAL.
TR A (Applications). G (General Review).
PT JA (Journal Article).
AB The paper describes the development and application of
microprocessor control to drill jumbos and roadheaders. The paper
commences with an introduction to the need for automated drilling
systems and the development of the first systems, and proceeds to
discuss flameproofing of the units and the extension to roadheader
guidance and control.

LG EN.

AN EI 8511-105382.
AU Jiang-Rong-chao.
TI APPLICATIONS AND DEVELOPMENTS OF ROTARY DRILLING IN CHINESE OPEN PIT
MINES.
SO Changsha Kuangshan Yanjiuyuan Jikan v 4 n 2 Jun 1984 p 51-60.
MJ MINES-AND-MINING.
MN Open-Pit.
ID ROTARY-DRILLING. ROCK-DRILLABILITY. ROTARY-BITS.
XR IRON-MINES-AND-MINING: Drills. MINING-ENGINEERING:
Peoples-Republic-of-China. ROCK-DRILLING: Analysis. ROCK: Testing.
CUTTING-TOOLS: Bits-and-Holders.
CC A405. A502. A504. A603. A901.

CD CKYJE7.

TR G (General Review). N (Numeric/Statistical). X (Experimental).
PT JA (Journal Article).
AB Mainly on the basis of the experiences gained from the applications
and developments of rotary drilling in Chinese iron open-pit mines
and the results of analyses and experiments made by the author on
rock drillability, electrical measurements of rotary drilling
parameters and investigation on rotary bits, the paper discusses the
superiority of rotary drilling and the conditions for developing
rotary drilling in China, and puts forward some measures and
suggestions for further raising economical benefits of rotary
drilling. (Author abstract) 11 refs. In Chinese with English
abstract.
LG CH.

AN EI 8312-104955.

AU Hoenig-Stuart-A. Zanoni-Raymond. Griffith-John-L.
IN Univ of Arizona, Dep of Electrical Engineering, Tucson, Ariz, USA.
TI APPLICATION OF ELECTROCHEMICAL TECHNOLOGY TO THE IMPROVEMENT OF
ROCK-DRILLING SYSTEMS.

SO Wear v 86 n 2 Apr 15 1983 p 247-256.

MJ ROCK-DRILLING.

MN Circulating-Media.

XR ELECTROCHEMISTRY. ROCK-DRILLS: Monitoring. MATERIALS-TESTING: Wear.
IS 0043-1648.

CC A405. A421. A422. A801.

CD WEARAH.

AB Studies of rock drilling with water-based mud have indicated the
existence of a current of electrons from the rock to the drill. If
this so-called 'normal current' is reduced to zero or is reversed by
an applied potential there is a significant reduction in drill wear.
The wear rate is enhanced if oxygen is bubbled through the drilling
mud and reduced if nitrogen is used, but in any case the electrical
effects can still be observed. Observation of the normal drilling
current with an oscilloscope has suggested that, when the drill is
'sharp', the normal current is a time-varying dc signal with most of
the signal levels at frequencies below 25 Hz. As the drill becomes
dull, the number of higher frequency signals and the overall signal
amplitude increase. It is suggested that this change in signal
frequency with wear can be used to monitor the condition of an
operational drill. 17 refs.

LG EN.

AN EI 8309-078170.

AU Lau-J-S-O.

IN AECL, Whiteshell Nuclear Research Establishment, Pinawa, Manit, Can.
TI DETERMINATION OF TRUE ORIENTATIONS OF FRACTURES IN ROCK CORES.
SO Can Geotech J v 20 n 2 May 1983 p 221-227.

MJ ROCK.

MN Fracture.

XR ROCK-DRILLING. ROCK-MECHANICS. MATHEMATICAL-TECHNIQUES.
IS 0008-3674.
CC A483. A921.

CD CGJOAH.

AB Determination of the true orientations of fractures in diamond drill cores obtained from deep boreholes in plutonic bodies is an essential requirement of the geoscience component of the Canadian Nuclear Fuel Waste Management Program. A reference line can be painted on the entire length of the rock core, indicating the orientation of the core, and the apparent orientation of the fracture can be measured from this reference line. This paper describes three methods that have been developed to convert the apparent orientation to true orientation, namely, stereographic projection, spherical trigonometry, and analytical geometry. The results obtained from these techniques were compared to assess their relative accuracy.
LG EN.

AN EI 8306-047432.
AU Desbrandes-R. Morin-P.
IN Inst Français du Pétrole, Rueil-Malmaison, Fr.
TI RECENTS DEVELOPPEMENTS EN FORAGE TELEGUIDE. (Recent Advances in Remote Control Drilling).
SO Rev Inst Fr Pet v 38 n 1 Jan-Feb 1983 p 63-81.
MJ ROCK-DRILLING.
MN Remote-Control.
IS 0373-532X.
CC A405. A732.
CD RFPTBH.

AB A new system has been developed for remote controlling of rock drilling operations. The system is based on wireline transmission of bottom hole data and control of bottom hole functions. Three main parts have been built: a directional unit; a bottom hole drilling parameters measuring unit; and a variable angle bent connector. The commercial results for the directional unit and the test results for the two other components are presented. The functioning of the equipment was satisfactory. 8 refs. In French with English abstract.
LG FR.

AN EI 8302-010571.
AU Stephens-H-S. Ed. Stapleton-C-A. Ed.
IN BHRA Fluid Eng, Cranfield, Bedfordshire, Engl.
TI PAPERS PRESENTED AT THE INTERNATIONAL CONFERENCE ON GEOTHERMAL ENERGY, 1982.
SO Pap presented at the Int Conf on Geotherm Energy, Florence, Italy, May 11-14 1982 Publ by BHRA Fluid Eng, Cranfield, Bedfordshire, Engl, 1982 2 vol, 835p.
MJ GEOTHERMAL-ENERGY.
ID REINJECTION. HEAT-TRANSFER. THERMODYNAMICS. DEEP-BOREHOLES. EIREV.
XR ROCK-DRILLING. HYDRODYNAMICS. FLOW-OF-FLUIDS: Two-Phase. ENVIRONMENTAL-IMPACT. HEATING: District.
CC A405. A615. A641. A643.
AB The proceedings contain 64 papers. The topics discussed are: exploration and development; modeling and reservoir evaluation;

drilling production and testing; corrosion; environment and reinjection; low-temperature, non-electric uses; high-temperature, thermodynamics, utilization; and hot dry rocks. Technical and professional papers from this conference are indexed with the conference code no. 01557 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.
LG EN.

AN EI 8302-013630.
AU Anon.
TI CRAELIUS LAUNCH - THE DIAMEC 260.
SO Ind Diamond Rev v 42 n 492 1982 p 268.
MJ ROCK-DRILLS.
MN Diamond.
IS 0019-8145.
CC A502.
CD INDRA9.

AB UK's Craelius Co. Ltd. recently announced the introduction of the Diamec 260 all-hydraulic, fully automated diamond core drill featuring an unique rod handling system and high productivity performances. Suitable for both surface and underground drilling, the new Diamec 260 is capable of core drilling to depths of 800 m with 43 mm diameter aluminium drill rods and a 46 mm diameter core barrel. The Diamec 260 can be run on fire resistant hydraulic fluids when in hazardous areas such as coal mines.
LG EN.

AN EI 8212-105309.
AU Petrakov-A-I. Krivorotko-O-D.
IN Donetsk State Plann, Des & Exp Inst of Coal Min Mach, UkrSSR.
TI RAZRUSHENIE GORNYKH POROD IMPUL'SNYMI STRUYAMI VODY. (Breakup of Rocks by Pulse Water Gun).
SO Ugol n 31672) Mar 1982 p 12-15.
MJ COAL-MINES-AND-MINING.
MN Hydraulic-Equipment.
XR ROCK-DRILLS: Hydraulic.
IS 0041-5790.
CC A503. A632.
CD UGOLAR.

AB A pulse water gun, designed for use in coal mines, is described. An automatic device provides triggering control of individual mechanisms, as a result of which optimum conditions of operation can be selected. The moving masses are balanced and provided with excess energy dampers. The high-pressure jet created by the water gun is compact and stable as regards its impact force. Water gun tests are described and results given. In Russian.
LG EN.

AN EI 8207-059524.
AU Keller-George-V.
IN Colo Sch of Mines, Golden, USA.

TI ELASTIC, MECHANICAL, AND ELECTRICAL PROPERTIES OF LOW-POROSITY ROCKS.

SO Log Anal v 22 n 6 Nov-Dec 1981 p 13-21.
MJ GEOPHYSICS.
MN Rock-Properties.
ID GEOTECHNICAL-ENGINEERING.
XR BOREHOLES: Logging. ROCK-DRILLING. MATHEMATICAL-MODELS.
IS 0024-581X.
CC A405. A481. A501. A921.
CD LGALAS.
AB Acoustic, mechanical and electrical properties were measured on suites of low-porosity rocks. Three rock types were represented in these suites; gneiss and schist, granite, and metarhyolite. Details of the measurement techniques and of the results obtained are presented. 29 refs.
LG EN.

AN EI 8203-024345.
AU Ryall-Patrick - J-C. Fowler-George-A. Manchester-Keith-S.
IN Dalhousie Univ, Halifax, NS, Can.
TI ELECTRIC ROCK CORE DRILL FOR DEEP OCEAN USE.
SO Offshore Technol Conf 13th Annu, Proc, v 4, Houston, Tex, USA, May 4-7 1981. Publ by Offshore Technol Conf, Dallas, Tex, USA, 1981 p 123-128.
MJ ROCK.
MN Sampling.
ID CORE-DRILLS.
XR OCEANOGRAPHY: Instruments. ROCK-DRILLS. GEOLOGY: Subaqueous.
CC A422. A471. A483.
CD OSTCBA.
AB This paper reviews the design of the drill and its subsequent development for deep ocean work. From its inception the drill has been powered and handled using a two-cable system which severely limited its depth capability. To alleviate this restriction the two-line system has been replaced by a contrahelically armoured triaxial cable. Power is transmitted at 2300 volts while signals from the drill are multiplexed and superimposed on the power lines. In addition the drill rig itself has been redesigned to allow operation on slopes up to 30 degree which may easily be encountered on oceanic ridges, the primary area of application. The new version has been used successfully on the Mid-Atlantic Ridge in June 1980 with core recovered in 10 to 11 attempts in water depths to 800 m. The use of the system will be extended to operating depth of 3500 m within the year.
LG EN.

AN EI 8201-008385.
AU Anon.
IN Ingersoll-Rand Co, Phillipsburg, NJ, USA.
TI HYDRAULIC JUMBOS PROVE THEMSELVES ON FIRST STAGE OF PAUTE PROJECT.
SO Tunnels Tunnelling v 13 n 4 May 1981 p 22-25.
MJ TUNNELS-AND-TUNNELING.
MN Construction.

XR HYDROELECTRIC-POWER-PLANTS: Underground. ROCK-DRILLS: Hydraulic.
IS 0041-414X.
CC A401. A405.
CD TUTUBV.

AB The hole-through on July 19, 1980 of the 6.2 km headrace tunnel at Ecuador's Paute River hydroelectric project marked a significant advance in that country's ambitious master plan for nation-wide electric power generation and distribution by 1985. At the same time, the project has provided a period of severe testing for the sophisticated hydraulic drilling equipment which was used to tunnel through the hard, igneous, metamorphic rock, sometimes in almost inaccessible locations. The article discusses the project design, geology, and equipment being employed.
LG EN.

AN EI 8201-006433.
AU Dahl-Kristen.
IN Ingenior Thor Furuholmen, Oslo, Norw.
TI COMPUTER CONTROL COMES TO HARD ROCK DRILLING.
SO Tunnels Tunnelling v 13 n 4 May 1981 p 12-15.
MJ ROCK-DRILLS.
MN Control.
ID DRILLING-JUMBOS.
XR TUNNELS-AND-TUNNELING: Construction. COMPUTERS: Applications.
IS 0041-414X.
CC A401. A405. A723.
CD TUTUBV.
AB Electronics and computer technology are rapidly spreading into the field of tunnel construction. Microprocessor controlled hydraulic drilling jumbos have been successfully used by a Norwegian contractor to drill in excess of half a million meters of hole, and are now ready for series production. The article discusses development of the machinery and automation program, method of operation, and other factors.
LG EN.

AN EI 8108-070354.
AU Baumann-Lothar. Heneke-J.
IN Bergbau-Forsch, Essen, Ger.
TI HIGH PRESSURE WATER JETS AID TBMs.
SO Tunnels Tunnelling v 13 n 1 Jan-Feb 1981 p 21-26.
MJ TUNNELING-MACHINES.
XR ROCK-DRILLING: Jet. TUNNELS-AND-TUNNELING: Testing.
IS 0041-414X.
CC A401. A405.
CD TUTUBV.

AB Performance improvement of cutter discs by the assistance of high pressure water jet was found to be a proportional function of the hydraulic capacity installed. In the case of tunnelling machines for diameters of 6 to 7 m this function theoretically results in electric drive capacity requirements which, if met, would entail serious technical and human engineering problems for tunnelling in underground mining operations. By systematic evaluation of full

scale tunnelling tests conducted for the purpose, all the possibilities for optimisation of this combined tunnelling technique were evaluated. Tunnelling advance in time, rotational speed of the drillings head, advance force and cutter depths are of essential importance in this respect. Further investigations were carried out to obtain relatively good heading rates by selective, high pressure water jets on particularly defined areas of the tunnelling head. In addition, successful and cost effective application of additives to high pressure water are discussed. A comprehensive discussion considers the technical and economic possibilities and the recognisable limits of this technology.

LG EN.

AN EI 8104-037022.

AU Baumann-Lothar, Heneke-J.

IN Bergbau Forsch, Ger.

TI ATTEMPT OF TECHNICAL-ECONOMICAL OPTIMIZATION OF HIGH-PRESSURE JET ASSISTANCE FOR TUNNELING MACHINES.

SO Proc of the Int Symp on Jet Cutting Technol, 5th, Hanover, Ger, Jun 2-4 1980 Publ by BHRA Fluid Eng, Cranfield, Bedford, Engl, 1980 p 119-139.

MJ TUNNELING-MACHINES.

XR ROCK-DRILLING: Jet.

CC A401. A405. A631.

AB The improvement of cutter disk performance by high-pressure water jet assist was found to be a proportional function of the hydraulic capacity installed. For tunneling machines of 6-m to 7-m diameters, this function theoretically results in electric drive capacity requirements which, if met, would entail serious technical and human-engineering problems for tunneling within underground mining operations. By systematic evaluation of full-scale tunneling tests, all possibilities for optimization of this combined tunneling technique were evaluated. Tunneling advance in time, rotational speed of the drillings head, advance force and cutter depths are of essential importance in this respect. Further investigations were carried out in view of obtaining relatively good heading rates by selective, high-pressure water jet assist of particularly defined areas of the tunneling head. In addition, successful and cost effective application of additives to high-pressure water are discussed.

LG EN.

AN EI 8011-085574.

AU Anon.

IN EIMCO Ltd, Engl.

TI CASE FOR HYDRAULICS.

SO Colliery Guardian v 228 n 3 Mar 1980 p 91-92, 95.

MJ ROCK-DRILLS.

MN Hydraulic.

IS 0010-1281.

CC A405. A502.

CD CLGUAL.

AB Benefits from a productivity point of view are discussed, also the

ergonomics of the hydraulics concept with the operator's health, comfort and safety in mind. Lower noise levels, oil-mist-free conditions, automation of controls, reduced vibration, increased penetration rates, improved drill steel life, lower energy consumption, efficient energy transmission and reduced overall costs lead to higher output.

LG EN.

AN EI 8003-024549.

AU Attebo-K.

IN Atlas Copco MCT Swed.

TI UPDATE ON HYDRAULIC ROCKDRILLING.

SO Natl Conf Publ Inst Eng Aust n 79/5 pt 2, Int Conf on Min Mach,

Prepr of Pap, Brisbane, Aust, Jul 2-6 1979. Publ by Inst of Eng,

Aust, Barton, 1979 p 351-358.

MJ ROCK-DRILLS.

MN Hydraulic.

CC A405. A502.

CD NPIEDX.

AB Recent field experience from tunnel driving for a hydro-electric power scheme is quoted to illustrate how the use of hydraulic rockdrills results in high advance rates and drilling economy. This paper also gives an update on hydraulic equipment for the lower end of the hole size/drift size spectrum. 5 refs.

LG EN.

AN EI 8002-014036.

AU Edmunds-P-L.

IN Atlas Copco Ltd, Engl.

TI OPERATIONAL BENEFITS OF HYDRAULIC PERCUSSIVE ROCK DRILLING.

SO Min Eng (London) v 139 n 214 Jul 1979 p 33-41.

MJ MINES-AND-MINING.

MN Drills.

XR ROCK-DRILLING: Hydraulic.

IS 0026-5179.

CC A405. A502.

CD MNEGAP.

AB This paper concerns itself largely with the operational benefits which fall conveniently into two parts: productivity benefits and ergonomic benefits. To put these into perspective, however, a brief look is first taken at the evolution of rock drilling. Benefits from a productivity point of view and their causes are then discussed, with a detailed examination of increased penetration rates, improved drill steel life, similar maintenance costs, lower energy consumption, efficient energy transmission and reduced overall costs. Also discussed are ergonomics or the science of having both machine and environment at optimum levels for the worker's health, comfort and safety. Benefits discussed here are lower noise levels, oil-mist-free conditions, automation of controls and reduction of vibration, etc.

LG EN.

AN EI 8510-092416.
AU Anon.
TI OPEN-PIT DRILL. TRENDS.
SO World Min Equip v 9 n 5 May 1985 p 25-29.
MJ MINES-AND-MINING.
MN Drills.
XR ROCK-DRILLS: Hydraulic.
IS 0746-729X.
CC A502. A504. A505.
CD WMEQDP.
TR G (General Review).
PT JA (Journal Article).
AB Greater productivity and safer operating conditions are the goals sought. Today's open-pit drill trends are greater automation, increased use of hydraulics, and more environmentally controlled units. The equipment is described.
LG EN.

AN EI 8508-071129.
AU Alimov-O-D. Manzhosov-V-K. Eremyants-V-E.
IN Acad of Sciences of the Kirghiz SSR, Automation Inst, Frunze, USSR.
TI ESTIMATE OF THE INFLUENCE OF IMPACT SYSTEM PARAMETERS AND THE MEDIUM BEING TREATED ON THE RATE OF IMPACTOR MOTION AFTER IMPACT.
SO Sov Min Sci v 20 n 2 Mar-Apr 1984 p 122-128.
MJ ROCK-DRILLING.
XR SHOCK-WAVES: Propagation.
IS 0038-5581.
CC A405. A502.
CD SMNSAT.
TR T (Theoretical).
PT JA (Journal Article).
AB Analytical expressions are obtained for determining the velocity of impactor motion after impact on a tool interacting with the medium being treated. Analysis of these expressions showed that the velocity of the impactor recoil from the tool depends on the relationship between the cross-sectional areas of these elements, their lengths, and a dimensionless parameter representing the ratio between the characteristics of the impact system elements and the medium being treated. 7 refs.
LG EN.

AN EI 8504-026289.
AU Savchenkov-N-G. Lashchenov-S-Ya. Vilvovskii-V-V.
Erchikovskii-R-G.
TI PROSPECTS OF USING AUTOMATED MANAGEMENT SYSTEMS IN EARTH-DAM CONSTRUCTION.
SO Hydrotech Constr v 18 n 5 May 1984 p 195-199.
MJ DAMS-EMBANKMENT.
MN Construction.
ID DAM-CONSTRUCTION. BURROW-PITS. ROLLING-OPERATIONS. EARTHWORKS. DAM-FILL.
XR MANAGEMENT: Control-Systems. ROCK-DRILLS: Hydraulic. EARTH-BORING-MACHINES.

IS 0018-8220.
CC A405. A441. A731.
CD HYCOAR.
TR A (Applications). G (General Review). M (Management Aspects).
PT JA (Journal Article).
AB The construction of earth dams contains a number of diverse technological processes (drilling, blasting, and excavating works in pits, transporting the materials from the pits to the dam, and segregating, grading, and compacting the soils) which are united by a common task - the creation of a continuous flow of the materials being placed in the dam. The experience of the introduction and functioning of the automated management system (AMS) of loading and transporting operations at the construction site the Nurek hydroelectric station - the Karat AMS - proved to be a quite characteristic favorable example in this respect, despite the considerable difficulties in introducing the system related to the lack of experience in using such systems in hydrotechnical construction, absence of pretrained personnel, and experimental character of the prototype of the introduced system. Operation of the system showed the possibility, in principle, of organizing operative management of all loading and transporting machines, revealed the potential possibilities of increasing labor productivity on loading and transporting operations, made it possible to improve management efficiency. 1 ref.
LG EN.

AN EI 8504-031271.
AU Doi-Yoshihiko. Yazu-Shunji. Nakai-Tetsuo.
IN Sumitomo Electric Industries Ltd, R&D Group, Itami, Jpn.
TI ROCK CUTTING PERFORMANCE OF SINTERED DIAMOND COMPACTS.
SO Sumitomo Electr Tech Rev n 23 Jan 1984 p 219-227.
MJ ROCK-DRILLS.
ID SINTERED-DIAMOND-COMPACTS. ROCK-CUTTING-PERFORMANCE.
XR DIAMONDS: Synthetic. CUTTING-TOOLS: Diamond.
IS 0376-1207.
CC A405. A482. A502. A606.
CD SETRAY.
TR N (Numeric/Statistical). X (Experimental).
PT JA (Journal Article).
AB Sintered Diamond Compacts have been widely used for cutting tools, wire drawing dies, dressers and drilling bits because of their good resistance to wear and toughness. For drilling bits, we have developed new sintered diamond compacts, which have high fracture and abrasion resistance resulting from a unique microstructure of a sintered diamond layer. The sintered diamond compacts recently developed are able to cut hard rock as andesite or granite.
LG EN.

AN EI 8504-031239.
AU Hoifodt-J-R. Wetlesen-T. Hakonsen-H.
IN Cent. for Industrial Research, Electronics Div, Oslo, Norw.
TI ROBOTICS RESEARCH IN NORWAY.
SO Model Ident Control v 5 n 3 Jul 1984 p 151-170.

MJ ROBOTICS.
 ID INDUSTRIAL-ROBOTS. MANIPULATORS.
 XR MATERIALS-HANDLING: Manipulators. ROCK-DRILLS.
 CC A502. A691. A731.
 CD MIDCDA.
 TR A (Applications). X (Experimental).
 PT JA (Journal Article).
 AB An overview is presented of the research and development programs taking place at different robot manufacturing companies in Norway. The grinding of plough-bodies, the use of a welding robot, computer controlled rock drilling machines, real-time multi-robot/multi-tasking control, and the use of an underwater manipulator are discussed.
 LG EN.

AN EI 8503-023872.
 AU Putintsev-N-N. Ryashentsev-N-N. Sobolev-Yu-I. Yushkin-V-F.
 TI MATHEMATICAL MODEL OF AN ELECTROMECHANICAL SYSTEM OF UNBALANCE DRIVES FOR A VIBRATION SOURCE.
 SO Sov Min Sci v 19 n 6 Sep 1984 p 506-509.
 MJ VIBRATORS.
 MN Drives.
 ID VIBRATION-MODULE. SEISMIC-OSCILLATIONS. PNEUMATIC-DEVICES. ELECTROMECHANICAL-SYSTEMS.
 XR MATHEMATICAL-MODELS. MINES-AND-MINING: Equipment. ROCK-DRILLS: Vibrations.
 IS 0038-5581.
 CC A502. A601. A921.
 CD SMNSAT.
 TR N (Numeric/Statistical). T (Theoretical). X (Experimental).
 PT JA (Journal Article).
 AB Mathematical models are presented for electromechanical systems of devices for two structural variants of a pneumatic vibration source: a vibration module with a load on supports with mechanical springs, and an unloaded vibration module with a pneumatic device for aligning the upper platform with the ground. The models proposed can be used in studies of the dynamic properties of vibrators and systems of electrical unbalance drives, for the purpose of selecting the best variant. The results obtained may also be used in calculating structural parameters for the vibration modules which would provide the most effective oscillation regime. 2 refs.
 LG EN.

AN EI 8501-008091.
 AU Gould-Robin.
 TI JAPAN TUNNELS FOR ENERGY.
 SO Int Constr v 23 n 11 Nov 1984 p 14-16.
 MJ TUNNELS-AND-TUNNELING.
 MN Construction.
 ID UNSTABLE-ROCK.
 XR HYDROELECTRIC-POWER-PLANTS: Pumped-Storage. ROCK-DRILLING: Equipment.
 IS 0020-6415.

CC A401. A402. A405. A611.
 CD INCOBU.

PT JA (Journal Article).

AB Construction of the Sabigawa pumped storage scheme in hills 150 km north of Tokyo is now well underway and the building of this 900 MW plant marks a milestone in meeting the demands of the energy hungry industries situated around Japan's capital. The Sabigawa project is the last of seven major pumped storage schemes being built by the Tokyo Electric Power Company (TEMCO) in the last 20 years. When it comes on stream at the end of the decade TEMCO will be able to utilize 5538 MW from pumped storage plants to meet the surge peaks in electric demand during daylight hours. Like Sabigawa many of these underground projects have been built into very bad rock conditions.
 LG EN.

AN EI 8411-118199.
 AU Pawlett-Steve.
 IN Engineering & Contract Record, Don Mills, Ont, Can.
 TI REALIGNING ACCESS ROAD KEEPS CAT ARM JOB ON TIME.
 SO Eng Contract Rec v 96 n 11 Nov 1983 p 14-16, 19.
 MJ HIGHWAY-SYSTEMS.
 MN Construction.
 ID GRANITE-ROCK-REMOVAL.
 XR ROCK-DRILLING: Explosive. GRANITE: Blasting.
 IS 0013-7804.
 CC A405. A406. A483.
 CD ENCRAS.
 AB At the big Newfoundland hydro-electric project, McNamara handles 500,000 m³ SUP*3 of rock to straighten the 18 km road to the main dam site. Using 15 Joy Airtrack drills at peak, the roadway operations included two D8s working 2 km ahead of the drill crew, which was followed by a mucking crew made up of two 980 loaders, four Cat D8s and 10 Cat 769 trucks hauling the blasted rock, while four Euclids brought in the granular road base. In the rock cuts CIL Powerfrac 75 and Amex dynamite were used in 65 mm blast holes, spaced 2 m apart.
 LG EN.

AN EI 8409-091279.
 AU Anon.
 TI OPTIMISATION DE LA FORATION ROTATIVE A LA CARRIERE SOUTERRAINE DE TAVERNY POUR REALISER LE BOULONNAGE ET LES TIRS. (Optimization of Rotary Drilling for Bolting and Blasting at the Taverny Underground Quarry).
 SO Ind Miner v 66 n 1 Jan 1984 p 3-10.
 MJ GYPSUM.
 MN France.
 XR QUARRIES-AND-QUARRYING: Equipment. ROCK-DRILLS: Optimization.
 CC A415. A482. A502.
 CD INMNCA.
 AB In a very thick layer of gypsum operated at the Taverny underground quarry near Paris, France all drilling equipment had to be adapted

to the large thickness of the layer. This has been achieved by using an electronically controlled jumbo rig that optimized the rotary drilling operation being performed for blasting and bolting. The article describes the equipment and its operation and discusses some practical results of its implementation. In French.

LG FR.

AN EI 8408-078050.
AU Pettitt-Roland-A. White-Anthony-A-L.
IN Los Alamos Natl Lab, Earth & Space Sciences Div, Los Alamos, NM, USA.
TI GEOTHERMAL ALTERNATE ENERGY: EXPANDING THE OPTIONS.
SO J Energy Eng v 110 n 2 Jun 1984 p 143-156.
MJ GEOTHERMAL-ENERGY.
XR ROCK-DRILLING. HEAT-TRANSFER: Fluids. ROCK: Fracture.
SOLAR-ENERGY.
CC A481. A615. A641. A657.
CD JLEEDS.

AB The extraction of usable energy from a hot dry rock (HDR) reservoir made by hydraulically fracturing the hot, but essentially dry rock between two deep drill holes has been successfully demonstrated at Fenton Hill, New Mexico. Depending on the location and depth of future HDR reservoirs, the extracted heat may be either high grade (for generation of electricity), or low grade (for direct-use space heating, food processing, etc.). The circulating hot water can also be used to augment energy production from other energy systems. When the HDR technology of drilling and fracturing in crystalline rock is coupled with solar energy production, excess summertime heat from solar collection facilities can be transferred and stored in manmade underground reservoirs for wintertime withdrawal and utilization. The same technology can provide huge, but easily accessible, heat sinks for reject industrial heat. 19 refs.

LG EN.

AN EI 8406-056885.
AU Wang-Sunjun. Zhang-Longren.
IN Coal Science Inst, Shanghai Research Inst, Shanghai, China.
TI EJ-30 TUNNEL-BORING MACHINE.
SO Coal Sci Technol (Peking) n 11 Nov 1983 p 15-17.
MJ MINES-AND-MINING.
MN Drills.
XR ROCK-DRILLS.
CC A502.
CD CSTPDL.

AB The EJ-30 tunnel-boring machine has been used satisfactorily in several collieries of China, with a total cumulative advance of 1501 m. The machine is 3 m in diameter, and is equipped with a domed cutterhead, non-standard bearings for the cutter body, big roller bearings, a cutterhead with a dust shield, a single man beam, a laser for alignment, a float gripper, a fixed-flow valve for the feeding oil, and various electrical protective devices, gas detectors, and warning systems. The machine is the product of the Shanghai No. 1 Petroleum Machinery Plant. In Chinese with English abstract.

LG CH.

AN EI 8404-036545.
AU Varner-H-M.
IN Bendix Corp, Englewood, Colo, USA.
TI FLEXIBLE ROTARY DRILL APPLICATIONS AND EXPERIENCE.
SO Min Eng (Littleton Colo) v 35 n 12 Dec 1983 p 1641-1646.
MJ ROCK-DRILL S.
MN Applications.
IS 0026-5187.
CC A405. A502.
CD MIENAB.

AB Under sponsorship of the US Bureau of Mines and Department of Energy, a new type of rotary rock drill was developed by Bendix Corp. It allows hands-off or remote production of holes for increased drilling speed and greater operator safety. This paper discusses various applications and experience in coal, metal/nonmetal mining, and civil engineering uses. Manual, remote control, and automatic roof bolter modules are also discussed.

LG EN.

AN EI 8401-003596.
AU Haimson-Bezalel-C. Doe-Thomas-W.
IN Univ of Wisconsin, Dep of Metallurgical Mineral Engineering, Madison, Wis, USA.
TI STATE OF STRESS, PERMEABILITY, AND FRACTURES IN THE PRECAMBRIAN GRANITE OF NORTHERN ILLINOIS.
SO J Geophys Res v 88 n B Sep 10 1983 p 7355-7371.
MJ GRANITE.

MN Physical-Properties.

XR GEOPHYSICS: Rock-Properties. GEOLOGY. PETROLOGY. ROCK-DRILLING.
IS 0022-1406.

CC A405. A481. A482. A483.

CD JGREAS.

AB This paper describes the distribution of fractures in two 1600-m-deep holes drilled into the Precambrian basement of northern Illinois and presents the results of permeability and in situ stress measurements in one of the holes. The primary motivation for these measurements lies in assessing the interrelationship between permeability, in situ stress, and natural fractures and the variation of these parameters with depth. The fracture system, in situ stress, and hydraulic properties of crystalline rock at depth are of critical importance to many practical problems such as geothermal energy development, disposal of nuclear wastes, underground pumped storage, and other subsurface civil works. 58 refs.

LG EN.

AN EI 7911-085265.
AU Nunn-J-W. Smith-J-F.
IN Min Res & Dev Establ, Bretby, Engl.

TI HYDRAULIC DRILLING EQUIPMENT.
SO Min Eng (London) v 138 n 213 Jun 1979 p 903-910.
MJ COAL-MINES-AND-MINING.
MN Hydraulic-Equipment.
XR ROCK-DRILLS: Hydraulic.
IS 0026-5179.
CC A503 A632.
CD MNEGAP.

AB The UK's Major Development Committee (MDC) Tunnelling was conscious of the need to distribute practical information on the relatively new technique of hydraulic drilling of coal and coal measure strata, so the Tunnelling Branch of the Mining Research and Development Establishment was commissioned to investigate and report on the state of the art in NCB (National Coal Board) mines. Considerable experience and printed information are now available on electric and pneumatic drilling, and this paper is intended to supplement this knowledge, particularly with regard to rotary and rotary-percussive hydraulic machines developed in Continental Europe and recently introduced into UK mines. Values quoted relating to strata and torque are arbitrary and are used purely as a means of classifying strata and machines.
LG EN.

AN EI 7909-073117.
AU Robertson-Joseph-L.
TI GIANT DRAGLINE EXCAVATES PHOSPHATE ROCK AT NEW PLANT.
SO Rock Prod v 82 n 6 Jun 1979 p 50-55.
MJ ROCK-DRILLING.
ID PHOSPHATE-ROCK. CHEMICAL-FERTILIZERS.
XR EXCAVATION. ROCK-PRODUCTS. FERTILIZERS: Phosphates.
IS 0035-7464.
CC A405 A505 A804 A821.
CD ROPRA5.

AB The author reports how phosphate rock is drilled and excavated to beneficiate rock for production into chemical fertilizers. Extraction is handled by two walking draglines, one with a 24-cu-yd bucket and the other with a 16-cu-yd bucket. Both machines are equipped with a leg on each side of the cab which allows the machine to move about 6 ft with each step in the direction that the cut is being developed. The dragline, equipped with the 24-cu-yd bucket excavates the phosphate rock matrix and is electrically powered, while the smaller diesel-powered unit works ahead of the larger machine removing the first 10 ft of the overburden, casting it in a previously mined cut.
LG EN.

AN EI 7909-071901.
AU Kuznetsov-V-A. Ivanov-E-G.
IN Kuibyshev Polytech Inst, USSR.
TI IZMERENIE PODACHI BUROVOGO INSTRUMENTA PO UGLU POVOROTA BARABANA BUROVOI LEBEDKI. (Measurement of Drilling Tool Feeding by the Angle of Rotation of Draw Works Drum).
SO Izv Vyssh Uchebn Zaved Neft Gaz n 12 1978 p 73-76.

MJ OIL-WELL-DRILLING.
MN Rigs.
XR EARTH-BORING-MACHINES: Measurements. ROCK-DRILLING: Measurements.
IS 0445-0108.
CC A405 A501 A511.
CD IVUNA2.

AB Designs of devices envisaged for the measurement of the feeding of the drilling tool according to the angle of rotation of the draw works drum, with automatic correction of errors caused by changes in the radius of winding of the pulley rope around the draw works drum, are considered. In Russian.
LG EN.

AN EI 7909-074930.
AU Anon.
TI STATION EXCAVATIONS IN HARD ROCK FOR THE WASHINGTON METRO.
SO Tunnels Tunneling v 11 n 3 Apr 1979 p 57-58.
MJ TUNNELS-AND-TUNNELING.
XR SUBWAYS: Stations. ROCK. EXCAVATION. ROCK-DRILLS: Pneumatic. CONCRETE-CONSTRUCTION: Shotcreting.
IS 0041-414X.
CC A401 A405 A681.
CD TUTUBV.

AB Ten of the Metro system's 86 planned stations are totally underground rock excavation projects, allowing for minimum disturbance to the neighbouring communities. All these underground stations are vaulted, cavern-like structures, designed without interior supporting columns. Two specialized machines are proving to be instrumental in moving the excavations along briskly while minimizing safety hazards. For multiple tasks of drilling, roof bolting and hole loading at the headings, subcontractor MacLean Grove Skanska selected four pneumatic Ingersoll-Rand Rampmaster jumbos, two at each station excavation site. The other machine on the job is the Stabilator Robot, a shotcrete application unit that sprays an air-water-concrete mix onto the tunnel roof and sides efficiently and with minimal risk to the operator from rock falls near the face. Contractor MacLean Grove Skanska reports that this is the first such automated shotcrete unit at work in the United States on underground excavation. The pneumatic jumbos and automatic shotcrete application are speeding the work with increased safety.
LG EN.

AN EI 7908-064659.
AU Hunter-W-J.
IN Atlas Copco Aust Ltd, Sydney, Aust.
TI HYDRAULIC ROCK DRILLS IN PRODUCTION AND DEVELOPMENT.
SO Australas Inst of Min and Metall, Melbourne Branch, Symp on Rock Breaking - Equip and Tech, Melbourne, Aust, Nov 1978 Publ by Australas Inst of Min and Metall, Melbourne Branch, Parkville, Victoria, Aust, 1978 p 15-24.
MJ ROCK-DRILLS.
MN Hydraulic.

CC A502.

AB The paper covers the history and development of electrical- and diesel-powered hydraulic percussion rock drills. It examines main design aspects and problems encountered in producing an efficient and reliable machine to cover fully the nominal hole sizes required for underground development, production drilling, and for general quarry work. The main design features and advantages of a hydraulic rock drill are: relatively low input power requirement to energy per blow (this being achieved by the use of an electric- or diesel-powered hydraulic system) and a specially constructed piston using a powered damper cylinder to absorb the recoil forces from the drill steel and reduce stresses on the drill, feed and hydraulic boom. 1 ref.

LG EN.

AN EI 7908-062261.

AU Ward-Terry-A. Bradley-Alan-J.
IN Hamersley Iron Ltd. Tom Price, Aust.
TI DRILLING PRACTICE AND INVESTIGATIONS INTO DRILLING TECHNIQUES AT THE MINE SITES OF HAMERSLEY IRON PTY. LIMITED.

SO Australas Inst of Min and Metall, Melbourne Branch, Symp on Rock

Breaking - Equip and Tech, Melbourne, Aust, Nov 1978 Publ by

Australas Inst of Min and Metall, Melbourne Branch, Parkville,

Victoria, Aust, 1978 p 33-41.

MJ IRON-MINES-AND-MINING.

MN Drilling.

XR ROCK-DRILLS: Electric.

CC A504.

AB Hamersley Iron Pty. Limited mines and processes iron ore from two orebodies. Conventional open pit mining methods are used at both sites in that material is drilled and blasted in benches, loaded by shovels and hauled to the primary crushers or dumped on waste or low grade material stockpiles. The present drilling fleet consists of eight high capacity Bucyrus Erie Rotary drills. There are significant physical differences between the ore types encountered at both mines which necessitate the drilling of smaller diameter blast holes at Paraburdoo than those at Tom Price. The drilling practice at each site is discussed, with examples of performance achievements under varying drilling conditions.

LG EN.

AN EI 7908-064658.

AU Rashleigh-Christopher.

IN Mount Isa Mines Ltd. Queensland, Aust.

TI ELECTRIC-HYDRAULIC DRILLING AT MOUNT ISA MINES LIMITED.

SO Australas Inst of Min and Metall, Melbourne Branch, Symp on Rock

Breaking - Equip and Tech, Melbourne, Aust, Nov 1978 Publ by

Australas Inst of Min and Metall, Melbourne Branch, Parkville,

Victoria, Aust, 1978 p 5-13.

MJ ROCK-DRILLS.

MN Hydraulic.

XR MINES-AND-MINING: Hydraulic-Equipment. PUMPS: Electric-Drive.

CC A502. A504. A632.

INFORMATION TECHNOLOGIES

AB Since 1975 two electric-hydraulic drills, a Robbins 11MD and an Atlas Copco COP1038, have been part of the production drilling fleet at Mount Isa Mines Limited's Isa Mine. As might be expected with innovative and technically more complex machines, breakdowns and maintenance problems have been greater than those experienced with pneumatic drifters. This has been especially so with the COP1038 but in co-operation with Atlas Copco, many modifications have been made to alleviate operating problems. Both machines have achieved good operator acceptance. This is the result of many factors, the major ones being the more acceptable environmental conditions, the relatively low amount of physical effort and the high degree of mechanization. 3 refs.

LG EN.

AN EI 7902-012292.

AU Kovacs-William-D.

IN Purdue Univ, West Lafayette, Ind.

TI VELOCITY MEASUREMENT OF FREE-FALL SPT HAMMER.

SO ASCE J Geotech Eng Div v 105 n 1 Jan 1979 p 1-10.

MJ ROCK-DRILLING.

ID GEOTECHNICAL-ENGINEERING. STANDARD-PENETRATION-TESTS.

XR SOIL-MECHANICS. ROCK-DRILLS: Testing. HAMMERS.

CC A405. A421. A483. A605. A931.

CD AJGEB6.

AB Field measurements of the velocity just before impact of a Borros AB

Standard Penetration Test (SPT) automatic trip hammer indicate that

the average delivered energy is 99% of the theoretical available,

free-fall energy. It is expected that other trip hammers used in

Europe, Scandinavia, and Japan also give close to 100% of the

theoretical energy during the performance of the SPT. In contrast,

the delivered energy varies from 25% to 80% in U.S. practice where

the cathead and rope system is used to 100% of that delivered when

trip hammers are used. Since it has been shown theoretically and

experimentally that the SPT blow count is inversely proportional to

the delivered energy, it follows that for the same soil conditions,

blow counts will vary where there are differences in delivered

energy. Thus, engineers are cautioned in the interpretation of SPT

data from countries where trip hammers are in use. Blow counts may

differ by 200% or 300% from U.S. practice. 16 refs.

LG EN.

AN EI 7901-003933.

AU Diehl-G-W.

IN Oy Tampella Tamrock, Finl.

TI AUTOMATION AND OPTIMISATION OF ROCK DRILL PARAMETERS IN HYDRAULIC

DRILLING.

SO Min Mag v 139 n 1 Jul 1978 p 38-39. 41. 43.

MJ MINES-AND-MINING.

MN Drills.

XR ROCK-DRILLS: Hydraulic. COAL-MINES-AND-MINING: Drills.

CC A502. A503. A632.

CD MMALAD.

AB The possibilities for automation and optimization of hydraulic

drilling are discussed. Some new automatic features developed by a Finnish firm for hydraulic rock drills are highlighted, and optimization of such key drilling parameters as impact frequency, impact energy, rotation speed and feed force are discussed. Under laboratory conditions it has been established that the breakage of fragments is related to the unit energy of one blow. The maxima found are generally not very pronounced and occur at different energies for different minerals. The controls in a hydraulic drill system are also discussed.

LG EN.

AN EI 7810-075914.
AU Thomas-Richard-A.
TI UNDERGROUND MINING EQUIPMENT: FLEXIBILITY AND PRODUCTIVITY ARE STILL THE WATCHWORDS.

SO Eng Min J v 179 n 6 Jun 1978 p 69-78.

MJ MINES-AND-MINING.

MIN Equipment.

XR COAL-MINES-AND-MINING: Equipment. ROCK-DRILLS.

CC A502. A503. A504. A505. A692.

CD ENMJAK.

AB The perennial race between underground mining technology and the profit squeeze finds technology still holding its own. Responsive to the pressures exerted by spiraling costs of labor, materials, energy, and compliance with government regulations, users and manufacturers of underground mining equipment continue to generalize innovative, productive means of maintaining the delicate profit balance necessary for survival of the industry. The new products covered include hydraulic drills and jumbos, in-the-hole (ITH) equipment, diesel and electric loaders of the LHD (load-haul-dump) variety, rail systems, and some auxiliary and support equipment. The more obvious trends in underground equipment are highlighted here, along with brief profiles of some of the equipment now on the market or in the testing stage. Equipment data are drawn largely from product literature. Specific products are singled out for discussion as being representative of all similar products.

LG EN.

AN EI 7809-067326.

AU DeMao-Peter-R.

IN AMAX Coal Co, Indianapolis, Indiana.

TI HEAVY SURFACE EQUIPMENT--INDUSTRY PROBLEMS AND SOLUTIONS.

SO Am Min Congr, Min Conv, Sess Pap, San Francisco, Calif, Sep 11-14

1977 Publ by Am Min Congr, Washington, DC Set 10, 18 p.

MJ MINES-AND-MINING.

MIN Equipment.

ID DRAGLINES.

XR COAL-MINES-AND-MINING: Equipment. PHOSPHATE-MINES-AND-MINING: Equipment. EARTHMOVING-MACHINERY. SHOVELS. ROCK-DRILLS

CC A405. A502. A503. A505.

AB The author discusses a number of problems that the mining industry must deal with in its use of heavy surface mining equipment, and then offers possible solutions to these problems. The paper deals

primarily with the largest mobile excavating equipment used in various mining and earthmoving operations in the world today, including walking electric draglines, large stripping and loading shovels, and large blast hole drills. Applications of this equipment in surface coal mining, hard rock mining such as iron, aluminum, copper and other ores, as well as in phosphate mining are examined.

LG EN.

AN EI 7808-057304.

AU Maurer-William-C.

IN Maurer Eng, Houston, Tex.

TI ADVANCED EXCAVATION METHODS.

SO Underground Space v 2 n 2 Dec 1977 p 99-112.

MJ EXCAVATION.

ID ROCK-EXCAVATION.

XR ROCK. TUNNELS-AND-TUNNELING. ROCK-DRILLING. TUNNELING-MACHINES.

CC A401. A405. A483. A502.

CD UNSPD9.

AB Novel excavation systems remove rock by four basic mechanisms: melting and vaporization, thermal spalling, mechanical breakage and chemical reactions. Lasers and electron beams have demonstrated that they can effectively cut narrow kerfs in rocks, but improved focusing systems will be required before they find widespread application. Rocket drills and electric drills currently being developed drill some hard rocks faster than conventional drills. Explosive drills being developed indicate potential for drilling granite and other hard rocks at rates up to 36 meters per hour. New systems for changing the bit cutting elements in deep wells without pulling the drillstem from the hole are under development. High pressure water jet drills and tunneling machines have indicated potential for drilling and excavating 2 to 5 times faster than conventional systems. 31 refs.

LG EN.

AN EI 7804-025704.

AU Smith-Mona-F. Ed.

IN NTIS, Springfield, Va.

TI GEOTHERMAL ENERGY. VOL. 2. MAY, 1975-APRIL, 1976: CITATIONS FROM THE NTIS DATA BASE.

SO NTISearch NTIS/PS-77/0560/1ENS, Search period covered May 1975-Apr

1976. Publ by Natl Tech Inf Serv, Springfield, Va, Jul 1977.

Available from Eng Index, New York, NY or NTIS 190 p.

MJ GEOTHERMAL-ENERGY.

MIN Bibliographies.

ID GEOTHERMAL-BRINES.

XR POWER-PLANTS: Geothermal-Energy. ROCK-DRILLING. HYDROLOGY.

CC A405. A444. A471. A615.

CD NTISDZ.

AB Federally-funded research on all aspects of geothermal energy and its development are contained in this collection. Hot-dry-rock systems, geothermal brines, magma systems, drilling, rock penetration, hydrology, and prospecting are studied. Electric power

production, space heating, engineering, equipment, materials, corrosion and process economics are also included. This updated bibliography contains 190 abstracts, none of which are new entries to the previous edition covering the period May 1975 through April 1976.
LG EN.

AN EI 7804-029784.

AU Herbert-Stan.

TI CONSUB--A DEVELOPING UNDERSEA TECHNIQUE.

SO Ind Diamond Rev Jan 1978 p 1-4.

MJ SUBMERSIBLES.

MN Remote-Control.

XR BOREHOLES: Diamond-Drilling. GEOLOGY: Subaqueous. ROCK-DRILLS:

Diamond.

CC A472. A481. A501. A502. A674. A732.

CD INDRAG.

AB This article discusses the design and operating capabilities of CONSUB 1, with special reference to underwater diamond drilling and core recovery for geological research. Designed and built by British Aircraft Corp. to the requirements of the Institute of Geological Sciences, the CONSUB 1 remotely-controlled submersible has proven itself an invaluable geological tool for the inspection and sampling of selected United Kingdom continental shelf areas. Salient features and operation of the submersible are described. 2 refs.

LG EN.

AN EI 7709-063534.

AU Jamison-Will-B.

IN Consol Coal Co.

TI IMPROVEMENTS IN ROOF BOLTING PROMISE GREATER SAFETY AND PRODUCTIVITY.

SO Min Eng (NY) v 29 n 7 Jul 1977 p 51-57.

MJ COAL-MINES-AND-MINING.

MN Roof-Supports.

XR ROCK-DRILLING: Mechanization. BOLTS-AND-NUTS: Testing.

ACCIDENT-PREVENTION.

CC A405. A421. A503. A605. A914.

CD MIENAB.

AB The current objective of the comprehensive research programs initiated and sponsored by the US Bureau of Mines is to bring an increased level of automation to the bolting operation: starting with simple functions to eliminate procedural steps, installing remote controls to move operators to a safer location, then moving to the development of automated bolter packages or modules, and finally marrying the bolter packages to the continuous miner. The final result will permit bolts to be set as close to the face as reasonable, with a minimum delay to miner operation. Test results with new machinery in underground coal mines are described. 1 ref.

LG EN.

AN EI 7705-035009.

AU Bruver-E-A. Mishchenko-V-V. Yablokov-G-P.

IN Tashkentgeologiya, Uzb SSR.

TI MEKHANICHESKIE PROBOOTBORNIKI DLYA BOROZDOVOGO OPROBOVANIYA
PODZEMNYKH GORN'YKH VYRABOTOK. (Mechanical Core Samplers for Furrow

Sampling of Underground Mine Workings).

SO Razved Okhr Nedr n 11 Nov 1976 p 35-38.

MJ ROCK-DRILLING.

XR MINERAL-EXPLORATION.

CC A405. A501.

CD RZONAV.

AB The results of experimental operation of manual electric and pneumatic core samplers for cutting furrow samples are analyzed. Suitable fields of application of these samplers are determined, both positive and negative aspects of their use are noted, and ways of improving the technology are indicated. In Russian.

LG EN.

AN EI 7701-004251.

AU Meier-Juergen.

IN Preuss Met, Goslar, Ger.

TI ENTWICKLUNGSSTAND DES HYDRAULISCHEN BOHRENS UND SEINE MOEGLICHKEITEN
ZUR VERBESSERUNG DER BOHRARBEIT--2. (Present Stand in the

Development of Hydraulic Drilling and Possibilities to Improve

Drilling--2).

SO Erzmetall v 29 n 6 Jun 1976 p 283-286.

MJ MINES-AND-MINING.

MN Hydraulic-Equipment.

XR ROCK-DRILLS: Hydraulic.

CC A502. A632.

CD ERZMAK.

AB Part 2 of this article examines recent technical advances in hydraulic drilling. These include: reduced noise levels, better energy utilization coupled with decreased power requirements, as well as a 50-100% improvement in performance. Thanks to such advances, the fully hydraulic hammer drill is expected to gain greater use in West Germany's mining sector. Areas that leave room for further improvement of hydraulic drilling are outlined. Two of these are the automatic control of drill arm movements, and centralized lubrication of drilling machine components. 12 refs.

In German.

LG EN.

AN EI 7612-082442.

AU Anon.

TI HYDRAULIC PERCUSSIVE DRILLS.

SO Min Mag v 135 n 3 Sep 1976, 7 p between p 194 and 205.

MJ MINES-AND-MINING.

MN Drills.

XR ROCK-DRILLS: Hydraulic.

CC A405. A502. A632.

CD MMALAD.

AB The comparatively recent and increasing interest evident in

hydraulic percussive drilling for mining and civil works in hard rock has prompted considerable research, design and development activity by manufacturers. Where high productivity and efficiency are important, particularly for projects and extensions requiring new capital investment, which are amenable to advanced methods and high sophistication, the trend is towards the selection of all-hydraulic drill jumbos, possibly with protective circuits and automatic control, rather than pneumatic percussive drilling. Advantages and disadvantages of hydraulic drilling are also discussed.

LG EN.

AN EI 7612-084674.
AU Misnik -Yu-M. Kilkeev-R-Sh. Brykov-S-I.
IN Leningrad Min Inst im. G.V. Plekhanov, USSR.
TI ISSLEDOVANIE KOMBINIROVANNOGO RAZRUSHENIYA MERZLYKH POROD.
(Investigation of Combined Breaking-up of Frozen Soils).
SO Izv Vyssh Uchebn Zaved Gorn Zh n 2 1976 p 64-68.
MJ SOILS.
MN Frozen.
XR ROCK-DRILLS: Electric. ELECTROMAGNETIC-WAVES.
CC A405. A483. A502. A711.
CD IVUOA5.

AB Based on an experimental investigation of the process of combined breaking-up of soils by the action of UHF electromagnetic energy and mechanical forces, numerical data are obtained on the relative reduction of traction loads and the value of energy consumption for the extraction of frozen soils. It is shown that the UHF electromagnetic field effect permits mechanical loads on working organs of the soil-breaking machinery to be reduced very considerably. In Russian.

LG EN.

AN EI 7611-073568.
AU Anon.
TI SNOWDONIA POWERHOUSE.
SO Tunnels Tunnelling v 8 n 2 Feb 1976 p 20-22.
MJ ELECTRIC-POWER-PLANTS.
MN Underground.
XR TUNNELS: Construction. ROCK-DRILLS. HYDROELECTRIC-POWER-PLANTS:
Pumped-Storage.
CC A401. A405. A611.
CD TUTUBV.
AB Using a three-boom pneumatic jumbo, the contractor has successfully driven 54 m of the D-shaped 6 by 5 m tunnel in a six-day week, as part of the preliminary works for the pumped storage power station. The tunnel, largely through slate, required rock bolting and shotcreting, and is one of two access ways for plant and materials to the underground machine and transformer chambers. The contractor is now reaching the end of the preliminary works, and despite rock stability problems which forced a change of portal location for the plant access tunnel, is on schedule.

LG EN.

AN EI 7611-072915.

AU Anon.
IN Concr Sawing and Drill Assoc, Harbor City, Calif.
TI CONCRETE SAWING AND DRILLING ASSOCIATION ANNUAL CONVENTION, TECHNICAL PAPERS, 1975.
SO Concr Sawing and Drill Assoc Annu Conv, Tech Pap, New Orleans, La, Mar 13-15 1975 Publ by Concr Sawing and Drill Assoc, Harbor City, Calif, 1975.
MJ CONCRETE.
MN Sawing.
ID WALL-SAWS. DIAMOND-BLADES.
XR SAWS: Diamond. DRILLS: Diamond. ROCK-DRILLS. DRILLING. CONCRETE-CONSTRUCTION: Joints.
CC A405. A412. A603. A605.
AB Proceedings include 7 papers that contribute to the role of coolant in the sawing of concrete with diamond blades; practical implications of applied research in industrial drilling; drilling and sampling rock; air, electric and hydraulic wall saws; sawing reinforced concrete with diamond blades; drilling in heavily reinforced concrete; and new markets for concrete and for sawed joints. Individual papers are indexed separately.

LG EN.

AN EI 7609-061503.
AU Anon.
TI ROTARY DRILLS DOMINATE IN OPEN PITS.
SO Eng Min J v 177 n 6 Jun 1976 p 191-194.
MJ MINES-AND-MINING.
MN Drills.
ID ROTARY-BLASTHOLE-DRILLING.
XR ROCK-DRILLS.
CC A502. A503. A504.
CD ENMJAK.
AB The superior efficiency of rotary blasthole drilling over other drilling methods has led to its primacy in almost all major open pits over the past decade. In taconites, holes up to 17 in. in diameter are now drilled to 65 ft in a single pass. Drills with pull-down forces of 130,000 lb and automated control of major functions are now common. These large diameter rigs are capable of penetration rates between 30 ft and 50 ft per hr in the hardest formations. Several rotary blasthole drilling rigs are highlighted, a new all-hydraulic crawler rig is examined in some detail along with redesigned bits for rotary blasthole drilling. Core drilling of large diameter bulk samples is also discussed. 2 refs.

LG EN.

AN EI 7609-061502.
AU Anon.
TI DRILLING: FASTER PENETRATION AND LARGER HOLES.
SO Eng Min J v 177 n 6 Jun 1976 p 154-157.
MJ MINES-AND-MINING.
MN Drills.
XR ROCK-DRILLS.

CC A502. A503. A504.
CD ENMJAK.

AB Numerous advances in drilling technology have been made in the last few years in response to the need for more efficient, higher-production mining equipment. Notable examples are the increasing use of all-hydraulic drills instead of partially or totally pneumatic rigs for drifting and stoping, and the introduction of large diameter blastholes to underground mining. In addition, breakthroughs have been recorded in tunneling, continuous hardrock mining, and raise boring with and without pilot holes. Relatively esoteric concepts and equipment are also being examined for potential use underground. 'Rock melting' bits and tunnelers, electric spark-producing and projectile-firing bits, high pressure water-assisted drills, 'swing hammer' miners, and other unusual mechanisms have been aired, and hopes for some of them run high.
LG EN.

AN EI 7607-048044.
AU Segsworth-R-S. Kuhn-K.
IN Univ of Toronto, Ont.
TI ELECTRICAL ROCK BREAKING.

SO IEEE Conf on Electr Process Heat in Ind, 12th Bienn, Conf Rec, Toronto, Ont, May 8-9, 1975 p 39-43. Publ by IEEE (Cat n 75 CH0953-0 1A), New York, NY, 1975.

MJ ROCK-DRILLS.

MIN Electric.

XR ELECTRIC-BREAKDOWN.

CC A405. A502. A701.

AB A technique has been developed for rock breaking which could be considered as an alternative to drilling and blasting. A series of tests and measurements are described involving initial dielectric breakdown achieved with high frequency power, followed by highly localized heating achieved by capacitor discharge energy. This heating causes relatively non-violent shattering of the rock. 15 refs.
LG EN.

AN EI 7604-023036.

AU Sachkov-V-G.

IN NETI, Novosibirsk, USSR.

TI INFLUENCE OF BIT GEOMETRY AND CUTTING-EDGE WEAR ON THE DESIGN OF A DRILLING MACHINE WITH A DIFFERENTIAL LINK TO THE EFFECTOR MECHANISMS.

SO Sov Min Sci v 11 n 2 Mar-Apr 1975 p 117-120.

MJ DRILLING-MACHINES.

MIN Electric-Drive.

XR ROCK-DRILLS: Electric. CUTTING-TOOLS: Bits-and-Holders. BOREHOLES.

CD SMNSAT.

AB Tests results with a rotary-percussive bit are reported showing technical characteristics of test rig and drilling process parameters. 2 refs.

LG EN.

AN EI 7603-018357.

AU Laswell-Gerald-W.

IN Conam Co, Boulder, Colo.

TI WANTED: ROTARY DRILLING TECHNOLOGY FOR IN SITU MINING SYSTEMS.

SO Min Eng (NY) v 28 n 1 Jan 1976 p 22-26.

MJ MINES-AND-MINING.

MIN Drills.

ID ROTARY-DRILLING-IN-SITU.

XR NUCLEAR-EXPLOSIONS: Underground. ROCK-DRILLS.

COPPER-MINES-AND-MINING. COAL-GASIFICATION. BLASTING.

CC A502. A504. A522. A524. A621. A932.

CD MIENAB.

AB Rotary-drilled in situ mining consisting of blastholes drilled into the resource body and loaded with sufficient explosive to fragment the host rock by expanding it into drilled void holes is discussed. Plates and diagram show procedure.
LG EN.

Bibliography

Basic Procedures for Soil Sampling and Core Drilling, by W.L. Acker, III 1974 Acker Drill Co., Inc. Scranton, PA.

Coring and Core Analysis Handbook, by Gene Anderson, 1975 Petroleum Publishing Company, Tulsa OK.

Batteries For Space Power Systems, by Paul Bauer, 1968 NASA Washington, D.C.

The Case For Mars, Penelope J. Boston, Proceedings of a Conference April 29- May 2 1981 at University of Colorado, Boulder CO. Univelt, Inc. San Diego, CA. 1984

Electromechanical Energy Conversion, David Brown and E. P. Hamilton III, MacMillan Publishing Co. New York, NY., 1984

The Surface of Mars, by Michael H. Carr, Yale University Press, New Haven CT., 1981

Radioisotopic Power Generation, by William R. Corliss and Douglas G. Harvey, 1964 Prentice-Hall, Inc. Englewood Cliffs, NJ.

The Wiley Engineer's Desk Reference, Sanford I. Heisler, John Wiley and Sons 1984

Pump Selection and Application, by Tyler G. Hicks, 1957 McGraw-Hill Book Company, Inc. New York, NY

The Mars One Crew Manual, Kerry Mark Joels, Ballentine Books, New York, NY. 1985

Space Communications, by Stanley Leinwell, John F. Rider Publisher, Inc. New York, NY. 1964

A Heat Transfer Handbook, by John H. Lienhard, Prentice-Hall Inc., Englewood Cliffs, NJ. 1981

The Viking Mission to Mars, Martin Marietta Corporation 1975

Advanced Drilling Techniques, William C. Maurer, Petroleum Publishing Co., 1980

Novel Drilling Techniques, by Dr. William C. Murer, Pergamon Press, New York, NY. 1968

The Drilling of Rock, by K. McGregor, C R Books Ltd, london 1967

Tables and Charts of Equilibrium Thermodynamic Properties of Carbon Dioxide for Temperatures From 100 K to 25000 K, by Charles G. Miller and Sue E. Wilder, 1976 NASA Washington, D.C. NASA SP-3097

The Exploration of Outer Space with Cameras, by Michael M. Mirabito, McFarland Publishers, 1983 Jefferson, NC.

The Geology of Mars, Thomas A. Mutch et al, Princeton University Press, Princeton, NJ. 1976

Electrical Power Generation Systems for Space Applications, NASA SP-79 1965 NASA Washington, D.C.

Models of Mars Atmosphere, NASA SP-8010, 1974 NASA Washington D.C.

Surface Models of Mars, NASA SP-8020, 1975 NASA Washington D.C.

The Martian Landscape, by The Viking Lander Imaging Teams, NASA Washington D.C., 1978

Machinery's Handbook, 22nd Edition, Erik Oberg et al, Industrial Press Inc. New York, NY 1981

Mission to Mars, by James E. Oberg, 1982 Stackpole Books, Harrisburg, PA.

Signals and Systems, by Alan Oppenheim and Alan Willsky, Prentice-Hall, Inc. Englewood Cliffs, NJ 1983

Theory of Machines and Mechanisms, Joseph E. Shigley and John J. Vicker, Jr. McGraw-Hill Book Company, New York, NY. 1980

Ice Core Drilling, John F. Splettstoesser, Proceedings of a Symposium, University of Nebraska, Lincoln, August 28-30, 1974, University of Nebraska Press, Lincoln Nebraska

Thermodynamics, Kenneth Wark, McGraw-Hill Book Company, New York, NY 1983

Geophysics of Mars, R.A. Wells, Elsevier Scientific Publishing Company, New York, NY 1979

Reports

"Planetary Mission Summary: Mars Surface Sample Return", Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California August 1974 NASA

"A Manned Mars Mission Concept with Artificial Gravity",
Hupert P. Davis NASA, June 1985 NASA-17317

"Mars Surface Science Requirements and Plan", James D.
Blacic, Mark E. Ander, David T. Vaniman, Los Alamos
National Laboratory, Los Alamos, New Mexico June 1985

"Electrical Power Systems for Mars", Robert J. Giudici,
Marshall Space Flight Center

"Surface Drilling Techniques for Mars", James D. Blacic and
John C. Rowley, Los Alamos National Laboratory, Los Alamos,
New Mexico, June 1985

"Design of a Samarium Cobalt Brushless DC Motor for
Electromechanical Actuator Applications", Bert Sawyer and
J.T. Edge, NASA, 1977

"Mars Polar Ice Sample Return Mission-1", Robert L. Stachle,
"Space Flight", 1976, 1977

"Site Selection for Manned Mars Landings: A Geological
Perspective", Paul D. Spudis, U.S. Geological Service,
Arizona

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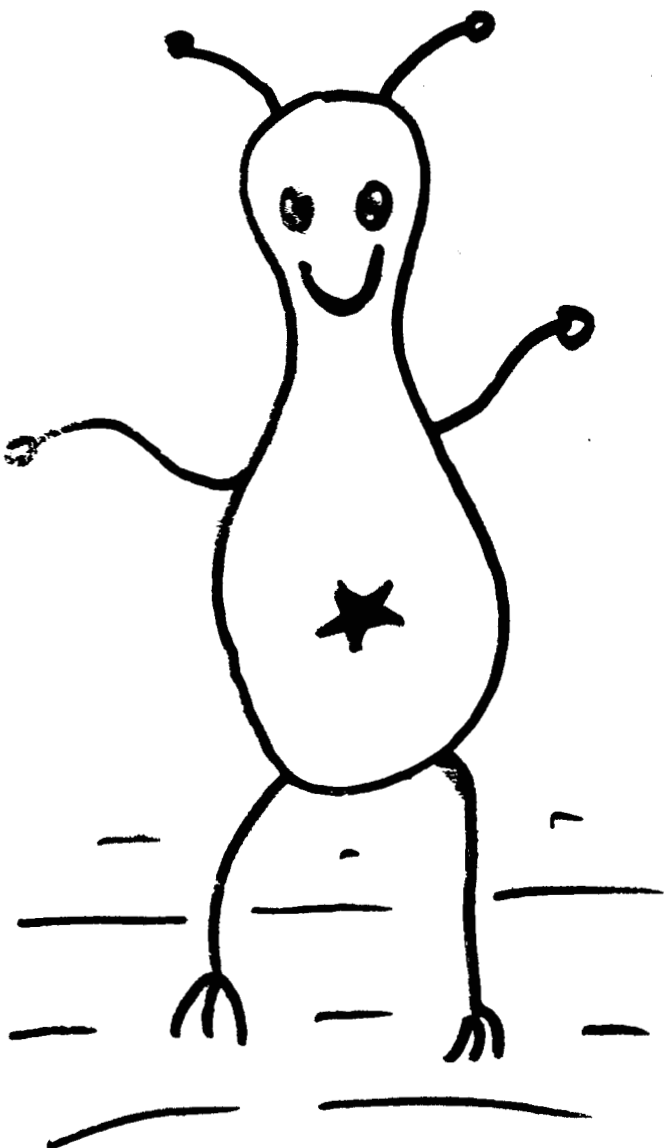
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ME 4182 GROUP #3

SEMI-AUTOMATED 10-METER MARTIAN DRILLING SYSTEM

Winter 1986

Mr. James Brazell



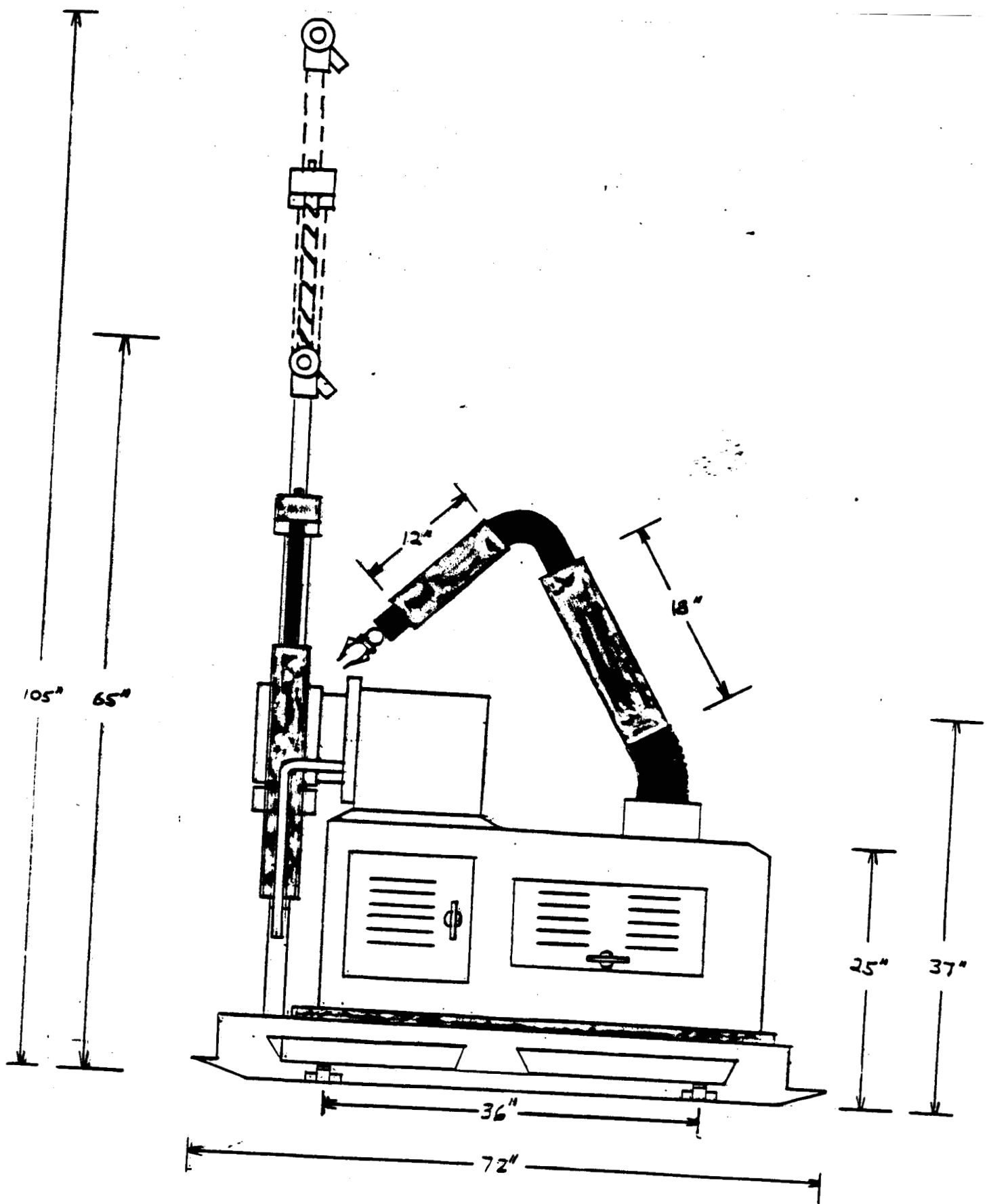
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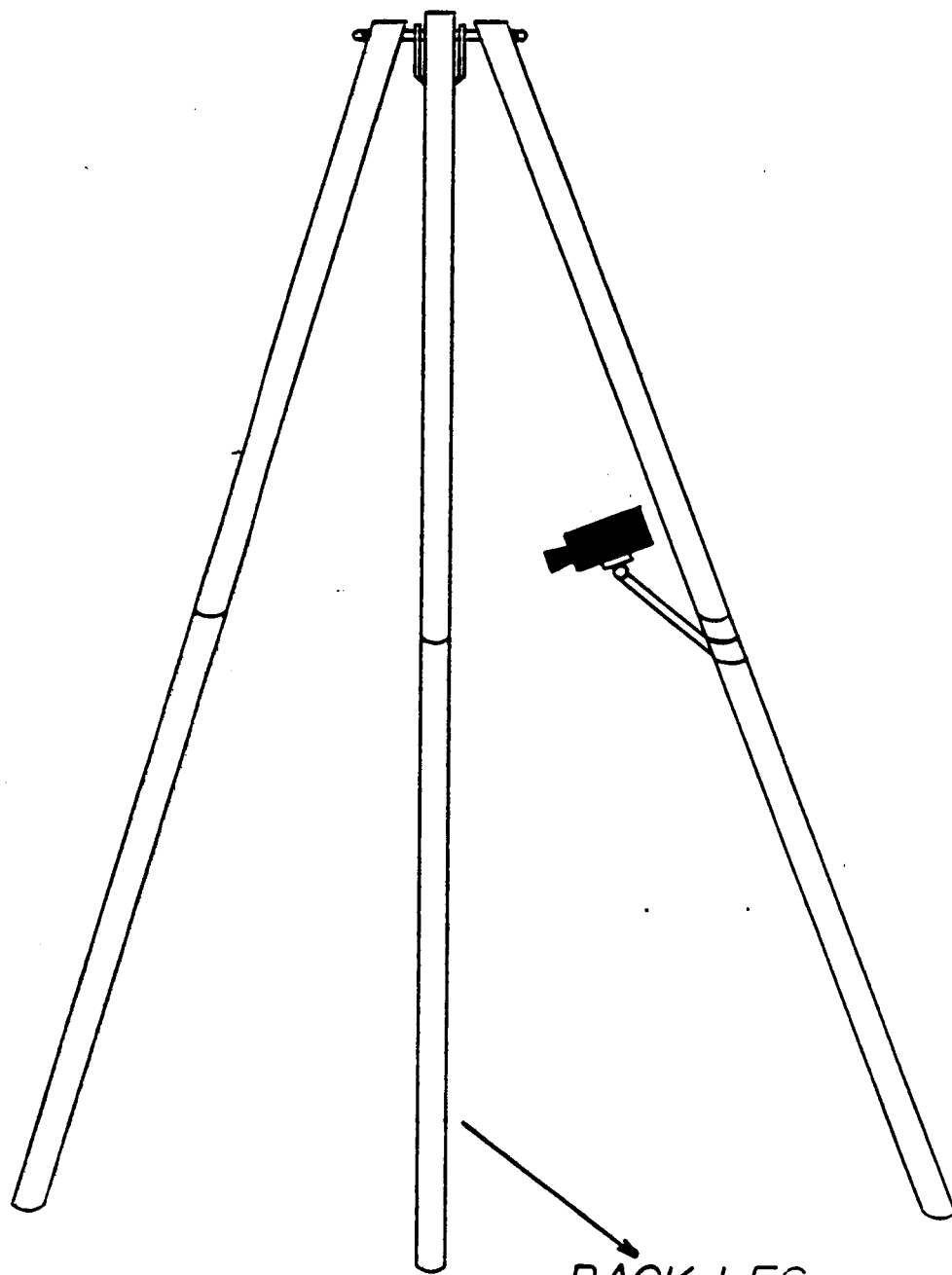
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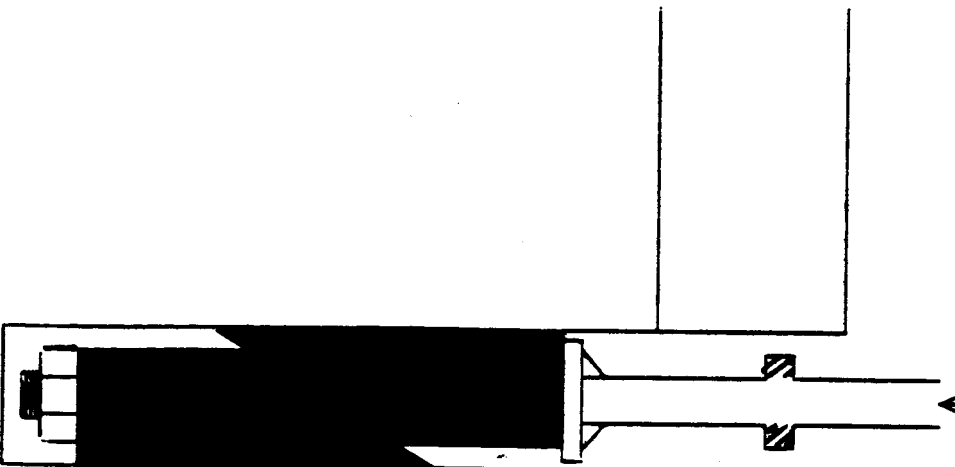


SCALE: 1" = 1'



BACK LEG

LINE OF FORCE



UNKNOWN
SOIL

ROCK

TUBULAR
T-HANDLE

XXXXX	XXXXX	2-27-86
LAST	UPDATED	2-28-86



TOLERANCE UNLESS
OTHERWISE NOTED:

IN: MM:

MATL: STEEL

SCALE: NONE

GEORGIA TECH
COLLEGE OF ENGINEERING

DEPT. ME4182 GROUP #3

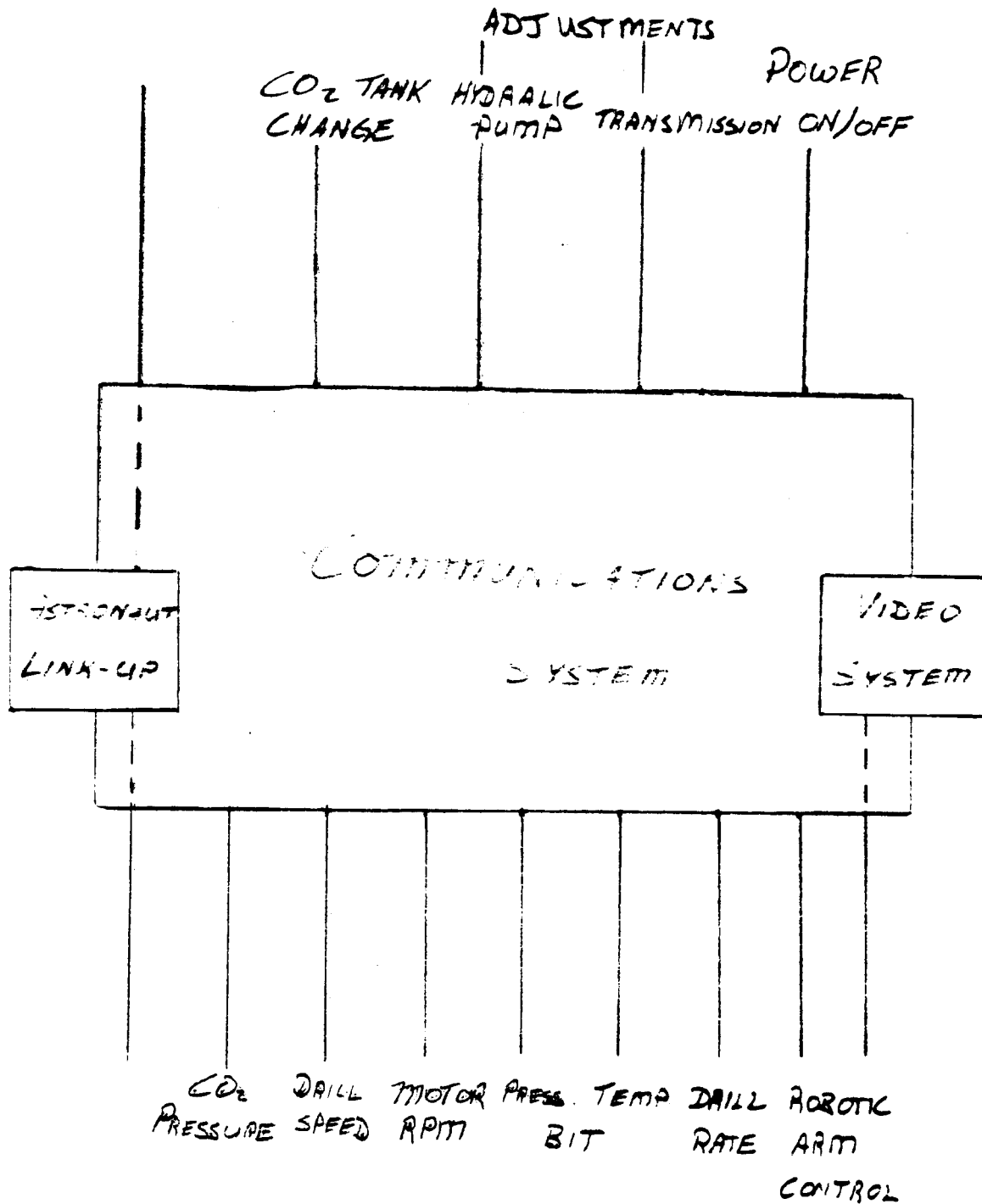
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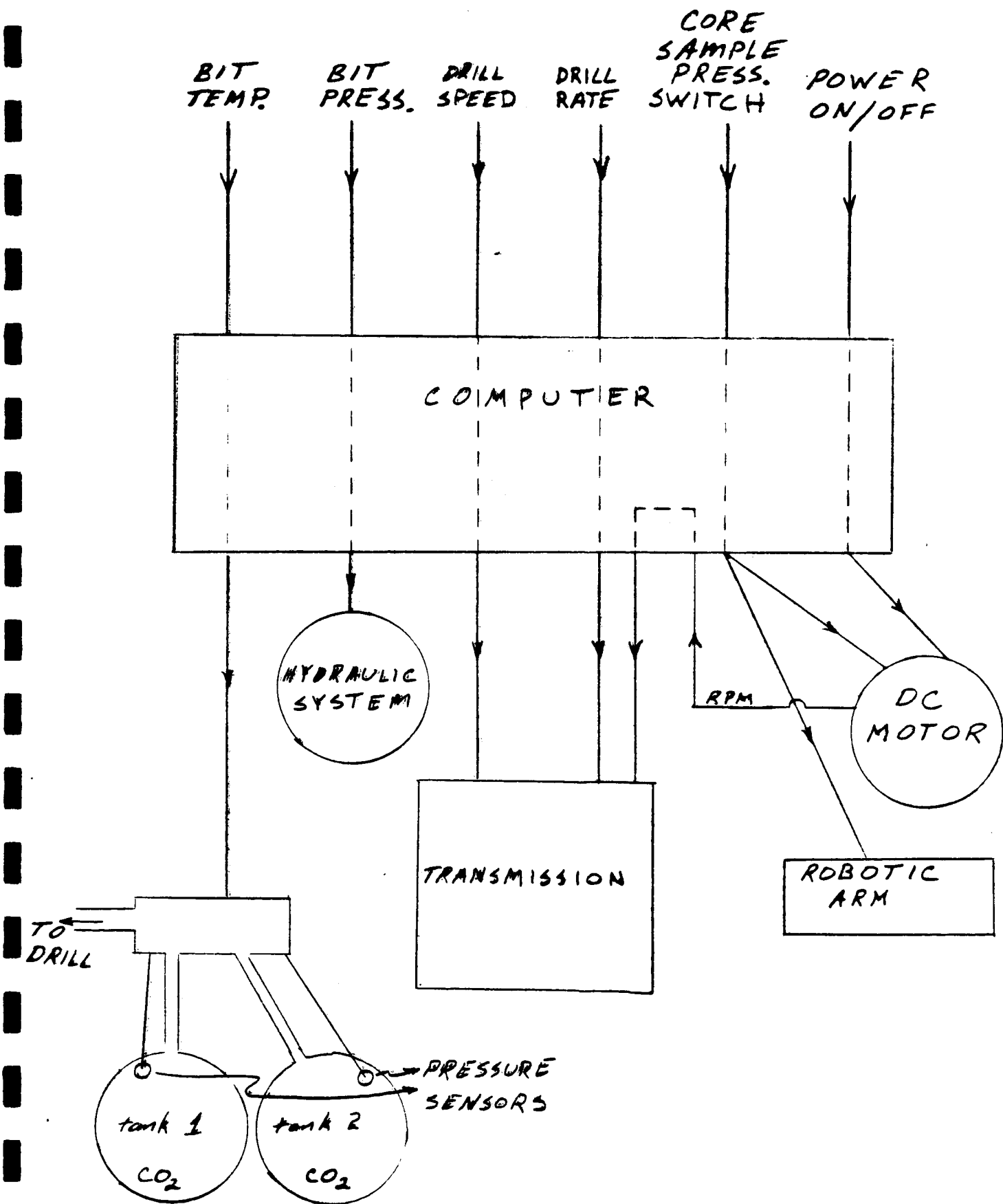
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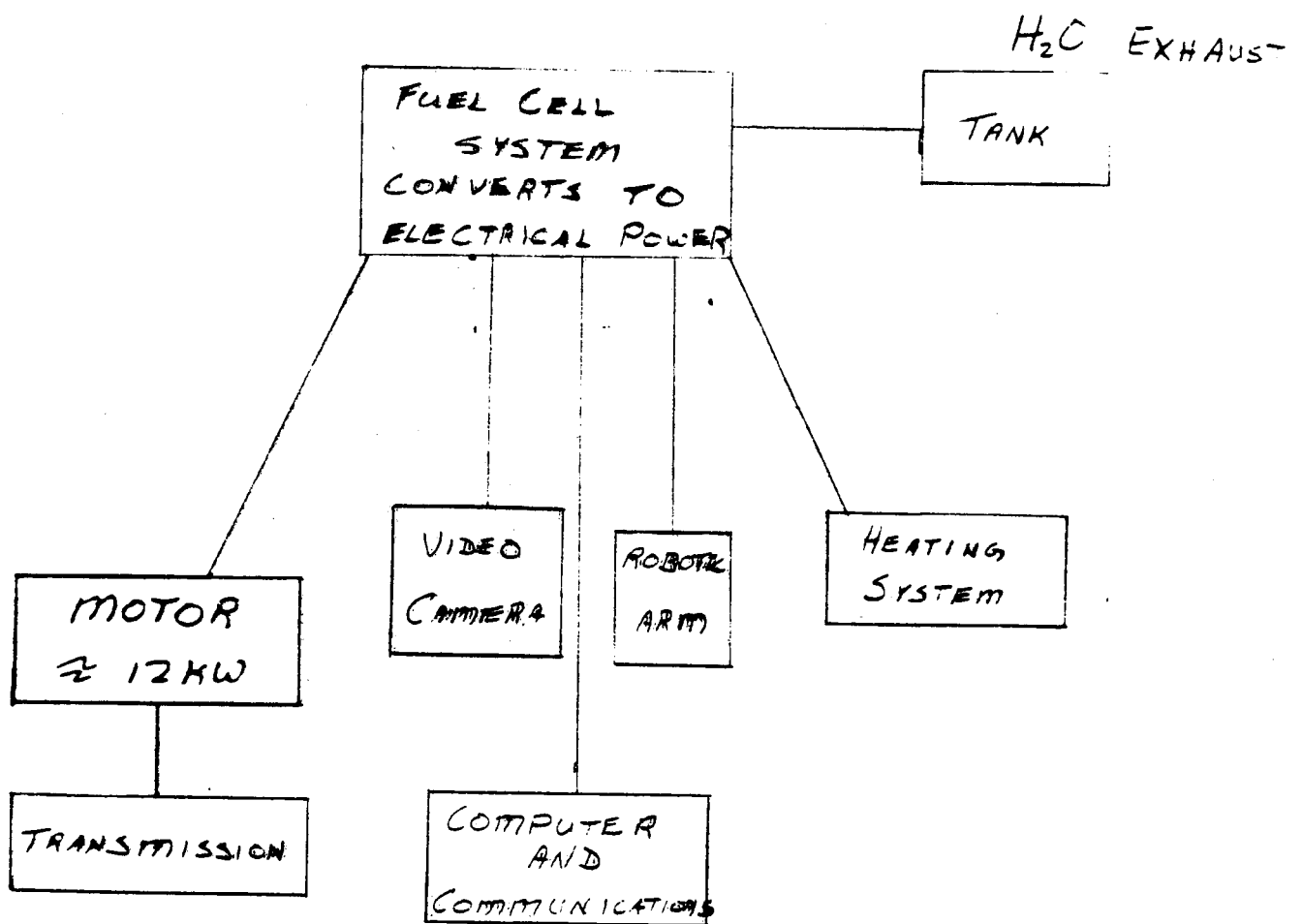
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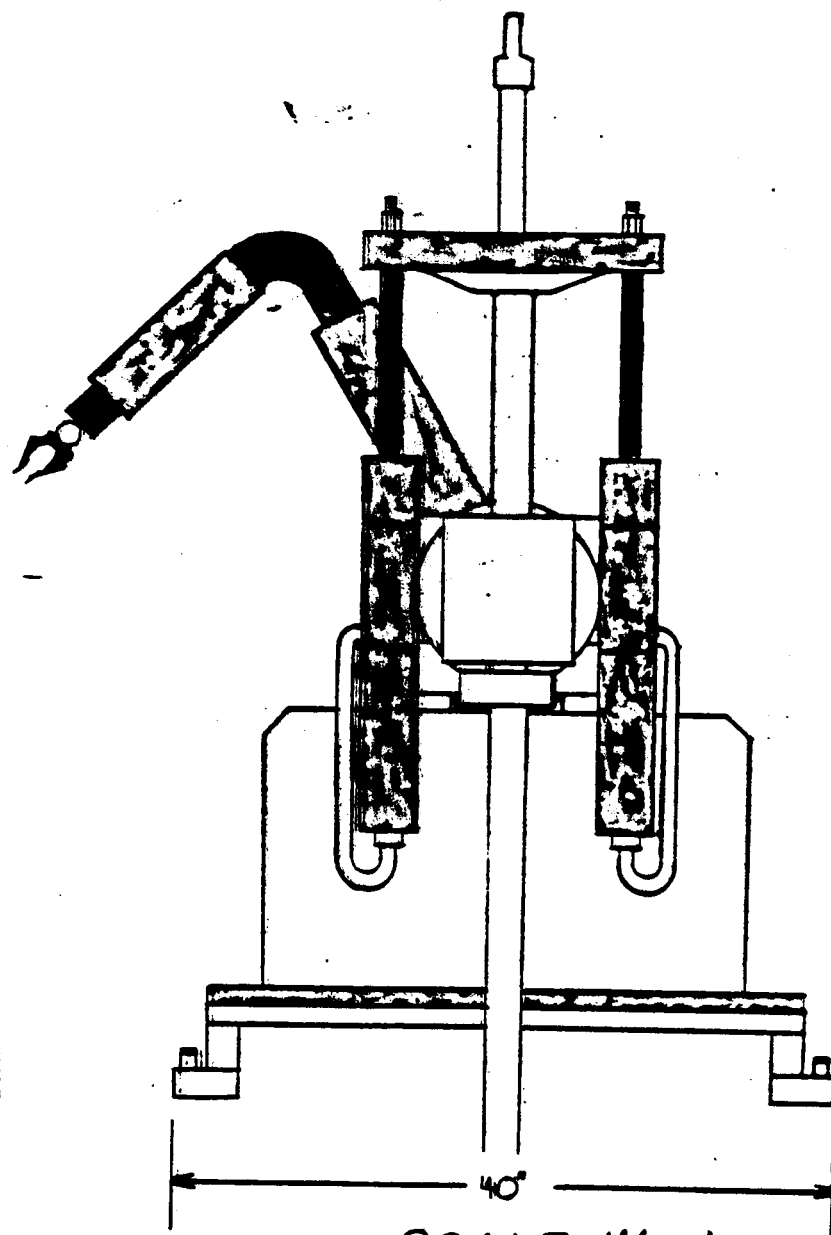
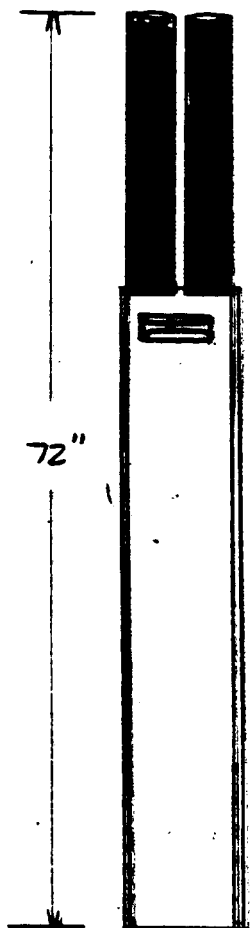


TRANSMITTING



POWER DISTRIBUTION





SCALE: 1" = 1'

5/16" UNF ASTM A574

soil

Rock

3/4"

